Gotchas from the Garbage Collector

REVIEWS
- Metamata Debug Enterprise 1.1
- IBM alphaBeans

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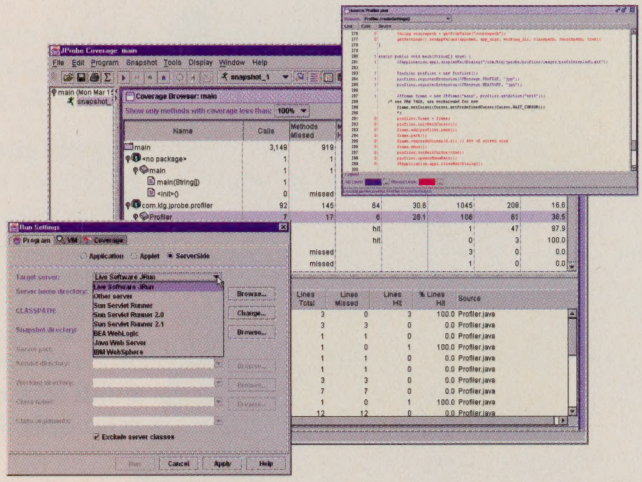

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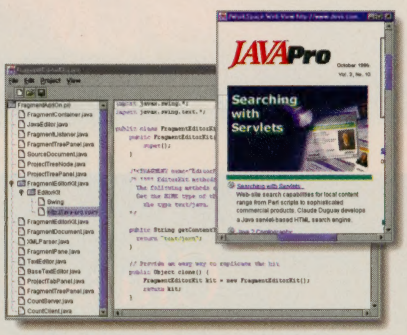

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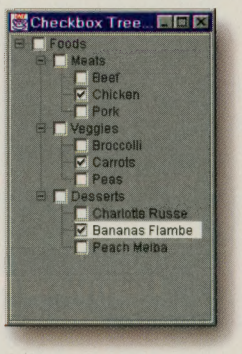

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Going to Zero

by Tyler Sperry
Editor in Chief

Celebrations are in the air this month. Whether you vote for 2000 or 2001 as the start of the new millennium, there's no debate that this next New Year's Eve will offer a worldwide party atmosphere the likes of which few of us have seen or will ever see again. Admittedly, the celebration may be a trifle muted for those in survivalist enclaves awaiting the collapse of Western civilization. But most of us see the arrival of a new year as an excuse for partying, followed by a massive hangover, and then another year of work like the one before.

Partying like it's 1999 doesn't work for everyone, of course. Some folks seem positively eager for the arrival of a year's-end calamity. While we don't have too many worries about Y2K issues in Javaland, some developers are surprisingly creative in their ability to see a bogeyman in every shadow. And nowhere is the syndrome more prevalent than in the online forums.

As a sample of the impending millenial madness, consider a recent online discussion regarding Sun's motives toward developers. A forum poster suggested that Sun's purchase and subsequent release of the StarOffice suite was some kind of evil plot against independent software vendors. The logic—and I use that term in a greatly extended sense of the word—seemed to be that a free office suite would somehow persuade companies to stop paying for Java software. Forget all the tools that Sun has made freely available to Java developers and how that's helped grow the market. Forget all those Fortune 1000 companies adopting Java for increased productivity and cross-platform portability for internal development. No, to hear this person tell it, Sun's StarOffice was simultaneously a piece of junk of no import and the end of the Java ISV market.

I must confess with some embarassment that I rose to the troll bait. I wasn't alone. Several others fell for it as well. Rather than considering the poster's Hotmail account as a clue to the real agenda of Sun-bashing, we tried posting reasoned responses, explaining why the premise was faulty. As if facts and logic could persuade a religious fanatic.

Components Are the Future

You can probably come up with your own reasons why free software isn't necessarily a bad thing. In the case of StarOffice, however, the advantages are even more obvious. At the time of Sun's announcement I had an interview with Brian Kroll, the product manager for the suite. Kroll took pains to explain the architecture of StarOffice, and promised that Sun would be providing both source code and API documentation for the front-end Java elements and the back-end components (written in C++). The component APIs are significant, he pointed out, because they allow ISVs to develop vertical applications that leverage the existing components. Kroll's example was a word processor customized for the needs of a legal office, but other possibilities come to mind easily.

To hear this person tell it, Sun's StarOffice was simultaneously a piece of junk of no import and the end of the Java ISV market

There's another point to be made on the StarOffice affair, and it relates to the changing nature of the software market. Scott McNealy has been credited with the observation that "software goes to zero." Unlike our excitable ISV friend, McNealy wasn't talking about wages. On the contrary, McNealy's point was that areas of the software market are shifting from the product model to the service model. The arrival of free software, whether it's a browser or an office suite, will not lessen the need for software developers. Web forum debates aside, the future looks especially good for Java developers. Which is something we can all drink to.

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What about JSP?

JavaPro's topics always seem to very timely (i.e., your XML coverage), but why has nothing (that I can find anyway) been written regarding JSP? I've searched both JavaWorld and DevX and couldn't come up with a thing as far as tips and/or tutorials.

Also, on a side note, any articles focusing on any of Sun's other Enterprise APIs, such as EJB, or of implementors of these APIs, such as Netscape Application Server 4.0 or Websphere, would be well received by this reader and I bet your other readers as well.

Thanks for a great publication and keep up the good work!

Ed Ludke

Editors respond: JavaServer Pages are relatively new, so consequently the number of authors who can write about them from experience is somewhat limited. We are actively recruiting authors for this topic, however, and you can expect several articles on JSP programming to appear in the months to come.

Servlet Engines

I read Larry O'Brien's article about the performance of servlet engines ("Stressed for Success," August 1999). I just want to know if he had performed any additional tests, for instance with JRun from LiveSoftware in combination with Apache. Also, has he had the chance to make the same test on Linux to confirm his results? He said in his article that he could not test on any platform other than Windows, but has he tested on Windows in the meantime? We use Linux and Apache for our Web site, what servlet engine would he recommend?

Larry's articles and columns are excellent and always very handy when I need answer.

Lars George

Larry O'Brien responds: As a matter of fact, I have retested Apache and JServ fairly extensively since the article went to press. In summary, the issue seems to be something anomalous about either the hardware or software on my Dell XPS running Windows NT. I have tested Apache + JServ on NT (on other boxes), Solaris, and Linux, and I generally see a much better performance profile than on the Dell the article was based on. However, the Dell machine continues to exhibit the same performance problems. Time being the precious commodity it is, it's highly doubtful that I'll pursue exactly what is going on with the Dell. We have decided to go to production using Apache and JServ running on top of Solaris. The moral of the story remains, though: Always test performance with automated tools.

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Reviews

Metamata Debug Enterprise 1.1
IBM alphaBeans

Metamata Debug Enterprise 1.1

Build a better bug trap

by Michiel de Bruijn

Quick Facts:

Metamata Debug vastly improves on the functionality found in most IDE debuggers and allows you to easily work with multithreaded and distributed code, no matter where it runs.

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If you use any of the popular Java integrated development environments, it might seem like there are much better ways to spend $1,200 than on a debugging product. After all, your IDE already comes with all the debugging features you could ever wish for, right? Not quite: The new Metamata Debug suite goes way beyond what your current tools have to offer.

Debugging Central

The various parts of Metamata Debug are accessible through a console application that lists all the Java code available as per your class path and allows you to attach to remote processes as well. Apart from some utility functions, the main applications available through the console are Audit, Metrics, and Debug.

Metamata Audit provides you with a diagnostic walkthrough of your code, and points out actual and potential problems. The Enterprise edition uses enhanced syntax checking—spotting the same errors the compiler would complain about, but with much more intelligible error messages—as well as over 50 more detailed rules designed to spot logic errors and even offer performance-enhancing suggestions. The Audit API allows you to extend this process with your own Java code to include custom rules.

The Metrics app doesn't necessarily help you write better code, but does provide you with various traditional code statistics (such as lines of code) that help you to see how your project is progressing. Its object-oriented metrics can also provide you with an early warning if parts of your application are getting out of control due to a flawed object model.

Metrics can be obtained at any level of your project (source files, classes, and so on) and various statistical functions are available to aggregate the data. Incremental updates from within your IDE are also supported. Once the code analysis is complete, it can be saved to a file, along with the various available graphs.

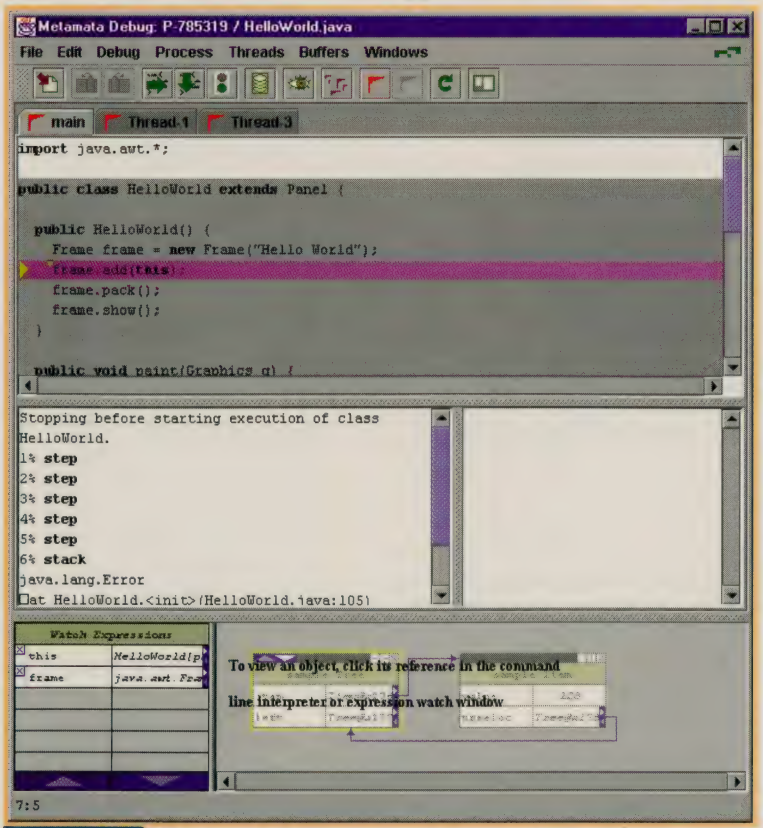
Abundant Functionality

The most exciting part of the Metamata package is, of course, Debug. It works with any local or remote application, regardless of the VM it is running on; see figure. As long as you've compiled your code using Metamata's own Java compiler (which *does* require at least version 1.1.5 of the Sun JDK to really work well), you'll get debugging functionality that matches or even exceeds what any IDE's proprietary debugger has to offer.

In addition to the usual fare, like breakpoints, assertions, single-stepping and data examination, Debug includes a quite elegant code/object browser and a command-line Java interpreter that allows on-the-fly evaluation of the most complex expressions. Debug's multithread support gives you completely independent access to each of your app's threads, making it almost *easy* to troubleshoot compound bugs related to thread interactions.

The fact that your Java code doesn't need to run on the machine you use for debugging makes working with applets and even embedded Java code much easier. If you're into client/server applications or Enterprise beans, you'll love the ability to attach to multiple processes running at the same time on different machines and troubleshoot communications between the various components.

So, is there any downside to using Metamata Debug? Not really, aside from minor annoyances, such as the licensing server that needs to be available on your network and is bound to a specific IP address (which can create problems for roaming laptop users). As with many Java products, speed and memory consumption can be disappointing—prepare to use a pretty fast PC with at least 128 MB of RAM for complex debugging sessions. And although Metamata Debug works fine with code running on any VM, the product is really designed to run on Sun's JDK 1.2. I had some major hassles getting the debugger and compiler to run on anything else. ■



Just Say Hello Metamata's Debug environment allows you to work with simple apps, such as the 'Hello World' example shown here, just as easily as with distributed multithreaded applications. A clean tabbed interface allows independent access to all threads in any of the processes that you've attached to at a given time.

Michiel de Bruijn lives in Rotterdam, The Netherlands, and spends his days as a networking and development specialist for an international media group. He seems to enjoy living on the bleeding edge of technology. Michiel always welcomes questions and comments: reach him at mdb@x42.net.

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Getting more than what you pay for

by Michiel de Bruijn

Quick Facts:

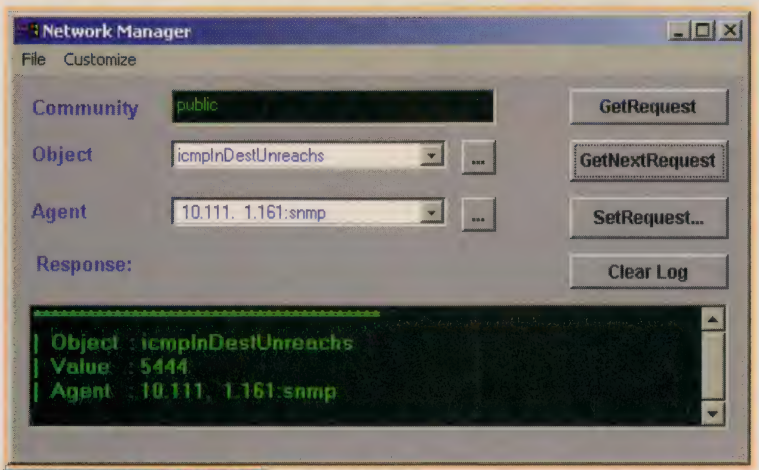
IBM's alphaWorks initiative brings you the latest in cutting-edge Java technology, including an impressive collection of freely available JavaBeans.

IBM alphaWorks
IBM Corp.
New Orchard Rd.
Armonk, NY 10504
Phone: 914-499-1900
Web: http://alphaworks.ibm.com/alphabeans
Price: Most components are freely available

If you ever wondered what having access to the Research and Development department of one of the most innovative computer companies in the world would do for you, make sure to check out IBM's alphaWorks Web site. What you'll find there is the very latest in software technology—most of it related to Java—and, best of all, IBM allows you to download it all right away.

Of course there's a catch: As the name of the site already indicates, this is all alpha-level technology, intended to give the bleeding edge crowd an early look at IBM's emerging products and to solicit feedback from developers. However, the level of functionality offered by most components is quite satisfactory, and IBM regularly makes new product builds available based on newsgroup feedback and bug reports.

The content of the alphaWorks site is extremely varied: On the opening page alone I recently found a JDK for Linux, an online auctioning client/server application and a Lotus Notes filing assistant sitting side by side, among many other products. The most exciting destination for most Java developers, though, will be the alphaBeans section of the site.



Keeping an Eye On the Net The SNMP component, shown in a quick and dirty demonstration program, is one of the components available for free from the alphaWorks Web site. SNMP comes with complete source code as well.

A Bean for Everyone

IBM's alphaBeans come in many different categories, and are definitely not limited to just a few flashy user interface components (although the ubiquitous ticker tape component *is* part of the collection). For users of IBM's VisualAge for Java, for example, there is a complete set of debugging beans that allow property and event monitoring, as well as inspection of the interactions between components that are driven by the VisualAge Composition Editor.

Users of *any* visual development environment will appreciate the easySwing beans. EasySwing is a collection of user interface components (a button group, checkboxes and radio boxes as well as text areas and fields) that can be easily wired together at the event level. It's almost trivial to do things like update a text-based field based on the selection of a checkbox.

For developers of networked applications, there's a whole set of beans implementing some of the most popular Internet protocols: FTP, POP3, SMTP, and even SNMP (see figure). In addition to the core protocol beans, you can also download a collection of auxiliary beans that offer additional functions (such as MIME decoding) or even implement a complete user interface for common functions.

Also of interest to the Internet community will be the impressive collection of XML beans. Whether you're just looking for a basic parser, or for more extensive support like a search component or even some complete user interface elements (such as an XML/DTD source viewer or a tree view), you won't be disappointed.

Authors of more conventional applications are well served by the alphaBeans site as well. Database developers, for example, will appreciate the Data Selector beans that facilitate the building of user interfaces for JDBC-compliant data sources. Other useful widgets include a calendar control and a surprisingly powerful task-scheduling component.

Want Source with That?

Although most alphaBeans come in bytecode versions only, IBM has recently started releasing source code for some beans as well—currently, full source is available for the FTP, POP3, SMTP and SNMP components, but more beans might follow in the future. The associated license is not exactly Open Source, but as with all the other alphaBeans, you are pretty much free to do whatever you like with the code (within reasonable limits and as long as you don't infringe on IBM's rights). But even if you don't plan on extending the components, the source code is often a great learning tool.

A number of alphaBeans have in the meantime "graduated" from the alpha stage, meaning they're now available as commercial IBM products. The first examples of this are a collection of basic user interface elements, a bean set to talk to iButtons (Dallas Semiconductor's range of smartcard chips), and a suite of masked input beans.

So, are alphaBeans something for you? The answer depends a bit on how comfortable you are using pre-release code, but since all components are available for free from the alphaWorks Web site, you can (and should) at least check them out. After all, how often do you get a chance to test-drive impressive technology for the cost of download? ■

Michiel de Bruijn lives in Rotterdam, The Netherlands, and spends his days as a networking and development specialist for an international media group. He seems to enjoy living on the bleeding edge of technology. Michiel always welcomes questions and comments: Reach him at mdb@x42.net.

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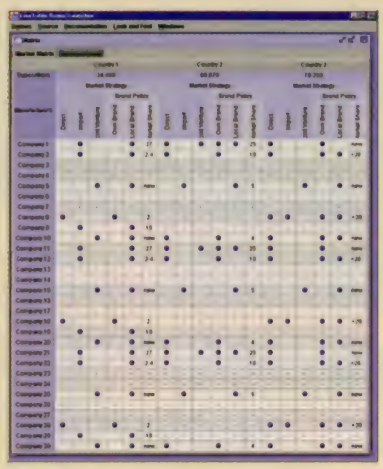

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CRYPTOCard
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Utilities

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WinA&D 3.0 is a software design tool that generates Java, Delphi, or C++ code from a class model and associated dictionary information. The generated code includes ready-to-compile class declarations with empty function frames. The code generator supports sophisticated features like nested classes, template classes, and overloaded functions, and you can map design elements to different code folders based on design namespaces. New features include interface and component objects to UML support, and operations of an interface can be defined once and then automatically incorporated into any class that implements that interface. $495 Standard; $1,295 Desktop; $1,995 Developer. Available now.

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Web: www.excelsoftware.com

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CommentMaster 1.0 is a debugging tool that helps you complete documentation on your Java code and increase reusability. It parses through Java files and fixes comments to match user-definable templates. It includes templates for files, classes/interfaces, and methods. CommentMaster supports all platforms. $99. Available now.

Objectsoft Inc.
350 West Erie, Ste. 200
Chicago, IL 60610
Phone: 888-OBJSOFT
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Metamata Debug 1.1

Metamata Debug is a visual Java debugger that reportedly can be used with any VM and any third-party libraries such as JNI and CORBA. Metamata Debug is not a jdb wrapper, but a self-contained debugger that also serves as a command line interpreter to directly call your Java methods. Features include support for JDK 1.1 and 1.2, and localization to Spanish. Metamata Debug provides breakpoints on uncaught exceptions, assertion violations, and at statements with errors. Contact for pricing. Available now.

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jtest! 3.0

jtest! 3.0 is a Java error prevention and error detection tool. In addition to performing white-box testing, which assures developers that a class is structurally sound and will not crash when passed unexpected inputs, jtest! 3.0 comes with new features including static analysis, black-box testing, and regression testing. jtest! 3.0 supports Windows 98, NT. $2,995 and up. Available now.

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NetComputing GmbH
Erzbergerstr. 131
Karlsruhe 76133
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COOL:Joe

COOL:Joe is an eBusiness development tool for delivering enterprise-scale distributed systems using Enterprise JavaBeans (EJBs). A second-generation Java development environment that incorporates advanced component modeling and generation capabilities, COOL:Joe enables you to implement EJB technology without having to worry about the underlying EJB code. Contact for pricing and availability.

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Applet Designer 2.0

Applet Designer is an add-in module for Visual Basic that provides one-click conversion to Java. Applet Designer Enterprise installs with Sun's Java 1.1, SuperCede's JADO (a 100% Pure Java implementation of Microsoft's Active Data Object), and OpenLink's client-side Java Database Connectivity (JDBC) drivers as well as server-side middleware. According to the company, the Applet Designer toolbar seamlessly integrates with the Visual Basic development environment for enhanced control. New features include support for User Defined Types, VB and VBA constants, and additional controls featuring the SSTab, TreeView, ProgressBar, and ImageList controls. Contact for pricing. Available now.

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Bluestone XwingML 1.0

XwingML is a platform for merging XML and Java code. XwingML (pronounced zwing-M-L) enables users to build XML documents that define the complete Java Swing Graphical User Interface. XwingML 1.0 is provided free of charge for internal use with full source code. Available now.

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New Products

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Formula One for Java is a spreadsheet development tool and end-user application written on the Java 2 platform. New features include support for the Java Foundation Classes/Project Swing technology, the Java 2D Application Programming Interface, InfoBus, and a model/view/controller architecture. Other new features include support for dates until the year 9999; specialized, pluggable calculation engines that are tailored to specific tasks; and modular .jar files that enable you to reduce download sizes by deploying only the functionality you require. Contact for pricing. Available now.

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JavaBeans

BeansDesigner (BD) 1.0

BeansDesigner (BD) 1.0 is a tool that allows you to create graphical beans. It directly generates 100% Pure Java code inside the class, so you don't need a third-party library. The code is fully modifiable after generation. The BD can generate static beans and resizable beans, and because the BD generates only the graphical part of the JavaBeans, you can generate all the kinds of beans that you find in the market. $49. Available now.

Streamgate Ltd.
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Web: www.probeans.com/

ObjectSwitch J-Adapter

ObjectSwitch J-Adapter is an Enterprise JavaBeans (EJB) interface for ObjectSwitch 3 Network-Resident Server. ObjectSwitch J-Adapter will allow CLECs, wireless carriers, and alternative network providers to create intelligent mediation and provisioning applications using EJB servers from multiple vendors and combine the resulting applications into a single seamless service offering. Service providers will be able to rapidly add and integrate scalable Java application services as elements in multiservice network offerings that integrate Web, PSTN, and high-capacity enterprise VPN services. Contact for pricing and availability.

ObjectSwitch Corporation
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Web: www.objectswitch.com

Virtual Instrumentation Beans (VIB) 2.5

Virtual Instrumentation Beans (VIB) is a suite of JavaBeans used to create Java-based graphical user interfaces (HMI, MMI, SCADA, and so on) for factory, laboratory, home, and facility automation applications. New features include the Virtual Instrumentation Constructor (VIC), a simple drag-and-drop prototyping system you can use to create applets without programming. The VIB components can be imported as components into most off-the-shelf Java development systems to take full advantage of the built-in framework and API. $399 Developer Edition; $1299 Pro. Available now.

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Books

Java Look and Feel Design Guidelines

This book provides essential information for anyone involved in the process of creating cross-platform Java applications and applets. Offers design guidelines for software that uses the Java Foundation Classes together with the Java Look and Feel. Written by the experts at Sun Microsystems Inc., this timely book provides many useful recommendations to designers for the use of the Java Look and Feel. 264 pages. $39.95. ISBN 0201615851.

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Members of the Premier Club of the Development Exchange (www.devx.com, $24.95 for six months, $44.95 for one year) can get each article's listings and associated files in separate ZIP files. For example, to download the individual code file associated with the October 1998 "Ask the Java Pro" column by Daniel F. Savarese, you would type in JP1098AP as the Locator+ code. Premier Club members can also access archives of all articles and related code ever published in *Java Pro*.

Java Zone
The Java Zone (www.java-zone.com) on the Development Exchange (www.devx.com) offers additional Java resources including product reviews, programming tips, weekly downloads, and discussion forums.

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Works With
JDK 1.2, JNDI 1.2, JNDI 1.1, LDAP Directory Servers

Making Enterprise Connections with JNDI and LDAP

Use JNDI as your network's "white pages" for easy access to distributed resources

By Scott Grant & Joseph Campolongo

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One of the advents in the enterprise technology space in the last few years has been the introduction of Lightweight Directory Access Protocol (LDAP) directory servers. Directory servers are designed to provide a standardized mechanism for storing, retrieving, and searching for information about entities in the enterprise: people, departments, organizations, etc. It is, in other words, a specialized type of database.

The emerging standard for these directory servers is LDAP. Sun has also introduced an enterprise extension API for accessing disparate naming and directory services called the Java Naming and Directory Interface (JNDI). JNDI provides an API that abstracts operations against naming and directory services, allowing you to use a single API in dealing with various and sundry naming and directory service providers.

The combination of these two technologies in the enterprise space provides a powerful mechanism for easily dealing with the data and metadata of heterogeneous devices. They provide a universal and uniform facility for browsing, accessing, and even providing convenient control capabilities for these devices. In this article we will show you an example of this and explain the technologies and how they work together.

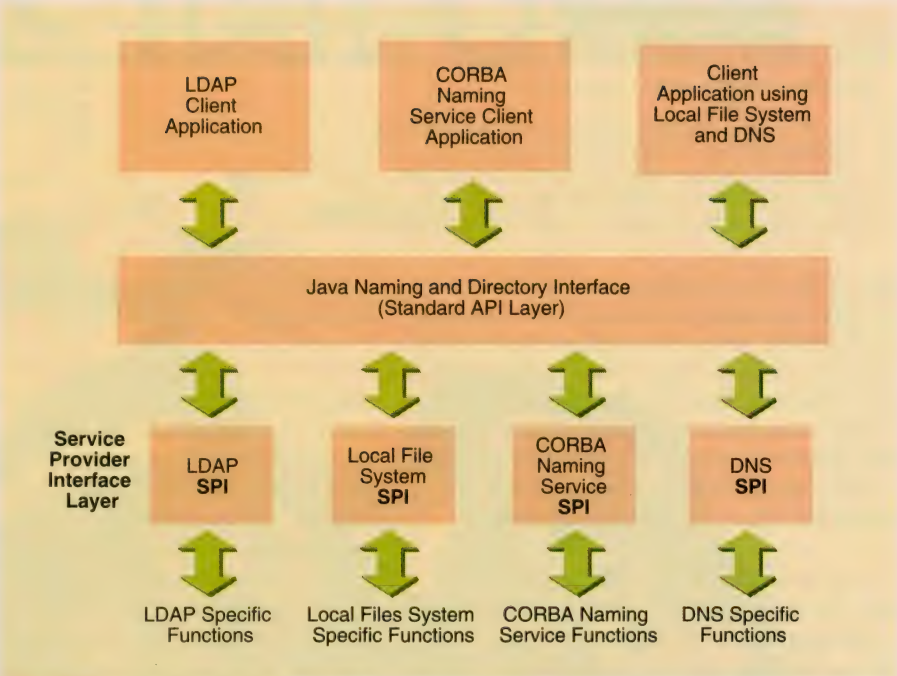
LDAP Client Application
CORBA Naming Service Client Application
Client Application using Local File System and DNS
Java Naming and Directory Interface (Standard API Layer)
Service Provider Interface Layer
LDAP SPI
Local File System SPI
CORBA Naming Service SPI
DNS SPI
LDAP Specific Functions
Local Files System Specific Functions
CORBA Naming Service Functions
DNS Specific Functions

Figure 1 JNDI Architecture The API is utilized by developers for seamless access to the various and disparate naming and directory services in the enterprise. The API is an abstraction that utilizes specific Service Provider Interfaces to access specific naming or directory services. Developers are not required to write SPIs, and their use by JNDI is often completely hidden from the developer.

What is LDAP?

LDAP grew out of X.500, also known as the Directory Access Protocol (DAP), an open standards-based directory service proposed by the International Telecommunications Union (ITU). The X.500 protocol, which was based on the OSI network model, was difficult enough to implement that a simpler protocol, LDAP, was designed to replace it. LDAP acts as a gateway between a client and the Directory Server Agents (DSA), or standardized directories, of X.500. Version 2 was the first widely used version of LDAP, and was defined in RFC 1777.

As LDAP became more widely used, it was given its own database, which was based on the X.500 data model, moving from a simple gateway between X.500 directories and clients to a complete directory service. The most recent version, LDAP version 3, found in RFC 2251, was ratified in December 1997 by the IETF, whose members included Microsoft, Sun, Netscape, Novell, and Innosoft (previously Critical Angle). It addresses the limitations of LDAP version 2, adds new features, improves compatibility with X.500, and better specifies how LDAP may be used with non-X.500 and stand-alone directory servers.

The directory server used with LDAP must conform to the LDAP data format, which is based on the X.500 model. It's made up of entries that consist of attributes that conform to a specific object class and that can be referenced by the entry's distinguished name. More specifically, an LDAP database contains entries, which are in turn made up of attributes. Attributes are name/value pairs, and can contain either text or binary data, depending on the definition of the attribute. Attributes may also be multivalued, meaning that an attribute may have more than one value per name. An entry must contain only the attributes listed by the object class to which it belongs. Object classes contain two lists of attributes—ones that must be present and ones that may be present—that define any entry that is that object class type.

In the LDAP server, entries are stored in the Directory Information Tree (DIT) and are referenced by Distinguished Names (DN), each of which must be unique. An entry's DN is made up of its Relative Distinguished Names (RDN), which must be unique relative to its siblings, and the DN of its parent in the DIT. An entry's RDN is one or more of its attributes. For example, the root of a DIT, called a domain, is usually an organization entry whose DN (and RDN) is the registered domain name of the company. For example, in "o=rapidlogic.com" o is the attribute name for organization contained within the entry referenced by "o=rapidlogic.com". As its immediate children, a company usually lists organizational unit entries, such as the entries referenced by the DNs "ou=engineering, o=rapidlogic.com" and "ou=marketing, o=rapidlogic.com." The RDNs of each of these entries are "ou=engineering" and "ou=marketing."

JNDI is designed to encompass a broad range of naming and directory services

As stated earlier, the entries to an LDAP directory server must conform to the directory server's object classes, which are part of the server's schema. A directory server's schema specifies all of the object classes and attributes that are available to be stored in the server. Furthermore, LDAP servers, as of version 3, are also expected to be able to expose their schema through the protocol for modification much like they expose their entries.

The LDAP protocol defines six operations that can be performed: binding to the server (similar to authenticating to the server), searching the server, comparing entries

Listing 1 Everything in Context The getInitialCtx() method creates an instance of InitialDirContext and returns it. The method also shows how to initialize InitialDirContext by creating a hashtable of properties that are passed into the object's constructor.

```
private Context getInitialCtx()
{
  // Set up our JNDI environment properties...
  Hashtable env = new Hashtable();
  env.put(Context.INITIAL_CONTEXT_FACTORY, INITCTX);
  env.put(Context.PROVIDER_URL, HOST);
  env.put(Context.SECURITY_AUTHENTICATION, "simple");
  env.put(Context.SECURITY_PRINCIPAL, USER);
  env.put(Context.SECURITY_CREDENTIALS, PASSWORD);
  try
  {
    return new InitialDirContext(env);
  }
  catch(NamingException e)
```

against the server, adding an entry to the server, modifying existing entries, and removing an entry from the server. Also defined by the LDAP protocol are three other services: referral, which allows directory servers to link to each other; replication, which allows for high availability; and encryption using SASL, SSL, user certificates, and Access Control Lists (although the final specification for ACLs have yet to be finalized).

What is JNDI?

Sun has provided developers with an easy mechanism for accessing information within these directory servers (or any naming/directory service). A few years back Sun introduced JNDI, which provided a standard, abstracted mechanism for accessing naming and directory services. It allowed easy navigation across directory servers, file systems, naming services (such as DNS), and so on.

One of the key benefits of JNDI is that it is designed to encompass a broad range of naming and directory services. It is built on an abstraction layer similar to JDBC. The JNDI API is used by developers to access any naming or directory service using the same API calls. The Service Provider Interface (SPI) layer underlies these APIs. SPIs are written to support a specific naming service or directory service. These SPIs are then plugged into the JNDI architecture (in the same sense that JDBC provides the same method calls, but needs different underlying drivers) and are transparent to the end user of the JNDI methods. Thus, the same API calls can be used for accessing a local file system, DNS, the CORBA Naming Service, LDAP directory servers, or any other naming or directory system that has an available SPI. (See Figure 1.)

Generally, SPIs are written by those who want to provide access through JNDI to a specific naming service or directory service. The manufacturer of a specific Directory Server may write the SPI, for instance, or the SPI may be provided by a third party and offer better performance than other SPIs for the same naming or directory service. (Such is the case with drivers for JDBC—some offer much better performance than others.) Many SPIs are already available for most of the naming and directory services. For instance, SPIs can be obtained from Sun for file system access, the CORBA Naming Service, LDAP, DNS, and so on. Other companies are also beginning to provide SPIs—IBM offers its own SPI for LDAP. For the purposes of this article, however, we will be using Sun's SPI for LDAP.

LDAP as Your White Pages

One of the benefits of LDAP is that it provides a universal mechanism for storing and accessing information about entities in the enterprise. This might be information about a person or a business group, or it might be about a physical device in the enterprise. For devices, LDAP provides a clean mechanism for storing the data and related metadata of a device in a normalized format. This data is then accessible in a standard way from any application in the enterprise. The data may even be accessible from another device if it contains code that can browse the directory and understands the format in which the device information is stored.

So devices can be browsed and modified in the same way that information about users or departments is browsed or modified. This provides a standard (and much cleaner) access mechanism than proprietary applications offer. Currently, the Distributed Management Task Force (DMTF) is working on mapping their Common Information Model (CIM) specification into a schema that can be used with LDAP directory servers. The CIM is, in part, a common object architecture for modeling device related information. CIM is a rather large and rather complex model, but we highly recommend you check it out at www.dmtf.org for further details. Our company, Rapid Logic, is looking at utilizing CIM within its own products, and is a member of the DMTF.

In the example application that this article is based upon, we will create a simple schema for device information in LDAP and use this to show you how to register your device information with the LDAP server, browse your device information, and access your devices with specialized Applet "customizers," using JNDI as our directory API.

The Program

The code included in this article implements a simple console-style Swing application that shows how to use JNDI to browse some "phantom" device information within the LDAP Directory Server. The console uses a JTree to display a hierarchical view of the device information and shows how to store serialized Java classes (in our case, special "customizer" Applet information) in the directory server for later access and for use in modifying device information (or controlling the phantom devices). We also demonstrate some of the basic aspects of JNDI, such as using JNDI to create new LDAP entries, remove entries, search for entries, and so on. We have based our LDAP examples around the Netscape Directory Server. (You can download the Netscape Directory Server from www.iplanet.com/downloads/testdrive/detail_8_7.html.)You can install it for a 30-day trial. A set of configuration files for the LDAP server is included with the application code archive.

The program is rather large, so we urge you to review the code provided with this article. We will highlight individual sections of code that detail the important aspects of using JNDI with LDAP. However, the application contains much greater detail on how to perform different functions in LDAP, including performance issues between various types of JNDI search mechanisms, etc. We recommend that you investigate the code and run the example application. The code also contains detailed comments in the relevant sections.

Initializing JNDI, Context, and DirContext

The method `getInitialCtx()` of our sample program shows how to initialize JNDI and retrieve the *initial directory context*. A Context is part of the abstraction JNDI provides; it represents a name to object binding in any given namespace. Also, any name used in an operation called on a specific Context instance is relative to that Context. DirContext represents a *directory context* and extends the basic Context interface; a DirContext allows Attributes to be associated with the Context. (For the purposes of this discussion, we will use *Context* to refer to both the base Context interface and the DirContext interface, interchangeably, when discussing operations that apply to both.) DirContext contains additional methods for getting and setting Attributes on a particular DirContext instance. Context and DirContext are contained within two basic JNDI packages—javax.naming and javax.naming.directory. These two packages are the ones you will most commonly use in your development.

A Context in JNDI provides a few basic methods to retrieve its name, the class of any object bound to it, or the object instance itself. (Keep in mind when dealing with an initial context or any sub-context, that any Name parameters passed to the context are relative to that context.) These methods typically return enumerations or an object instance. The methods `list()` and `listBindings()` of Context, and

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Listing 2 SearchResult Attributes This section of code uses the returned enumeration of SearchResult objects to obtain the associated attributes for each of the SearchResult objects.

```
while (enumDev.hasMore())
{
  SearchResult sr = (SearchResult)enumDev.next();
  Attributes attributes = sr.getAttributes();
  …
  NamingEnumeration ne = attributes.getAll();
  while (ne.hasMore())
  {
    Attribute attr = (Attribute) ne.next();
    String attrID = attr.getID();
    NamingEnumeration values = attr.getAll();
    . . .
    while (values.hasMore())
      child.add(
        new DefaultMutableTreeNode(values.nextElement()));
  }
}
```

the `search()` method of DirContext return a NamingEnumeration (a JNDI class derived from Enumeration that throws an exception) of JNDI specific class types: NameClassPair, Binding, and SearchResult, respectively.

A NameClassPair class represents just the Context name and the class of any object bound to the name (bound to the Context). The Binding class extends NameClassPair and represents the Context name, the class of the object bound to the name, *and* the actual object itself (returned as an Object reference). SearchResult extends Binding, and contains Attribute information for a DirContext as well, since it is returned by the `search()` method, which is specific to DirContext (only DirContexts have Attributes).

The Context method `list()` will return an enumeration of NameClassPair objects, and the `listBindings()` method of Context returns an enumeration of Binding objects. Context also provides a method called `lookup()`, which will accept a Name relative to the Context instance, and return any object associated with that Name. The `search()` method of DirContext always returns enumerations of SearchResult instances. The DirContext `search()` method has the ability to return either just the name and Class information in the SearchResult, or the name, class, and object instance based upon parameters that are passed in to the `search()` method. (This will be discussed in detail in the following "Searching with DirContext" section.)

You initialize JNDI through the creation of an initial context object. You create a set of properties which are passed in as a single parameter (as a hashtable, usually) to an initial context class constructor. One of these properties specifies a Factory class that is used by JNDI (and is supplied by the underlying SPI implementation) to create Context or DirContext instances specific to the naming or directory service you intend to use. (In other words, there is a specific Factory class for LDAP that knows how to create objects that implement the DirContext interface, and that represent LDAP data.) There are two types of initial context classes: InitialContext for naming operations and InitialDirContext which provides access to directory operations as well as naming operations. From the initial Context class you can obtain instances of context or DirContext classes (which may also be considered sub-Contexts) that represent a name in the namespace, a directory path, an LDAP distinguished name, etc. The JNDI Context and DirContext interfaces provide additional methods that you should investigate (see the JNDI documentation at http://java.sun.com/products/jndi/1.2/javadoc/index.html). We'll discuss some of them in the remainder of this article.

The sample program method `getInitialCtx()`, shown in Listing 1, creates and returns an instance of InitialDirContext. The method shows how to initialize InitialDirContext by creating a hashtable of properties that are passed in to the object's constructor. The first property, INITIAL_CONTEXT_FACTORY, is where you will specify the appropriate Factory class for the SPI you want to use. In this case we are using the LDAP SPI so we use "com.sun.jndi.ldap.LdapCtxFactory" (in the INITCTX variable). This tells JNDI which Factory to use to create objects. The next property, PROVIDER_URL, specifies the URL for the directory or naming server—in our case this is the LDAP server at port 389 or "ldap://localhost:389." The remaining properties specify the type of security items to use, such as the SECURITY_AUTHENTICATION property which in our case is "simple," but could also be SSL or SASL; the SECURITY_PRINCIPAL which is a user name; and the SECURITY_CREDENTIAL which is a password. In our case we use a user name and a password that are predefined in the sample database set up by the Netscape LDAP server when it was installed (this user has Directory Administrator privileges).

JNDI specifies a number of exceptions, of which one of the most common is the NamingException. As you can see, the sample program's `getInitialCtx()` method creates the hashtable with the appropriate properties, then passes this into an InitialDirContext object it creates. If initialization is successful given the properties supplied, then an InitialDirContext object is created and returned. If anything fails, a NamingException will be thrown.

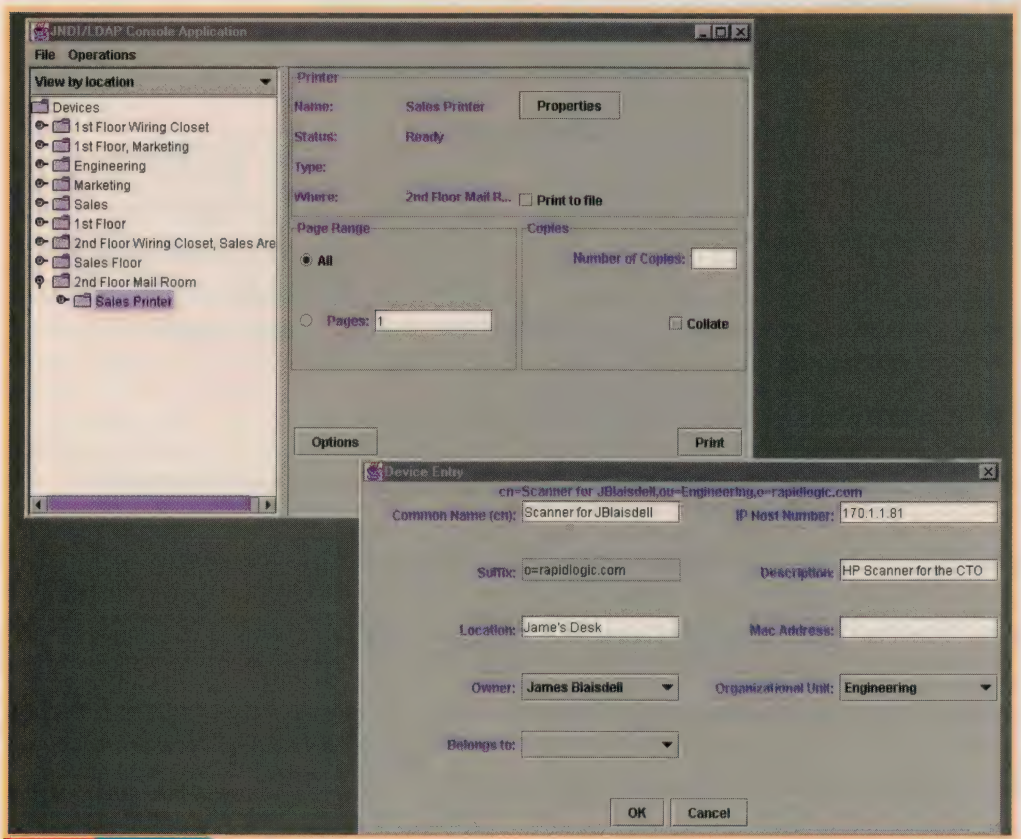


Figure 2 Valid Entry This figure shows the creation dialog and the various attributes that make up an entry.

Listing 3 New Entry When adding an LDAP entry for a device, a separate console dialog creates a BasicAttributes object from the data entered into the fields of the dialog and uses the initial context to create this entry.

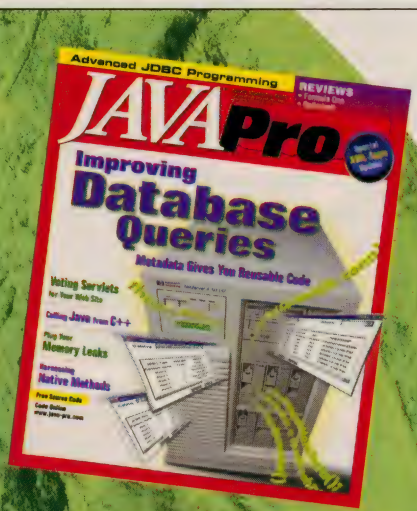
```
String dn = lblDN.getText();
try
{
  BasicAttributes attributes = new BasicAttributes();
  attributes.put("o", txtSuffix.getText());

  String tmp = "";
  if ( (tmp = txtLoc.getText()) != "" )
    attributes.put("l", tmp);

  if ( (tmp = txtDesc.getText()) != "" )
    attributes.put("description", tmp);

    . . .

  BasicAttribute attr = new
BasicAttribute("objectclass");
  attr.add("top");
  attr.add("netdevice");
  attributes.put(attr);

  initCtx.createSubcontext(dn, attributes);

  . . .
}
catch . . .
```

Searching with DirContext

When the application runs, a hierarchy is presented in the window's left scroll pane as a JTree. Above this tree is a JComboBox that gives the user a drop-down selection of display types. This lets the same information, about the same devices, be displayed in different ways. A list may be viewed by the device names, by the location attribute of the device, by organizational unit association, or by group association. There are four methods in the sample application code that perform each display operation; `displayByName()`, `displayByLocations()`, `displayByOUs()`, and `displayByGroups()`. Each of these methods demonstrates a search and retrieval of some set of attributes. Then it performs some manipulation of the attributes, and then it displays them in the tree in the specified format.

The JNDI DirContext interface defines a number of different methods. One of the primary methods is `search()`. The `search()` method has a number of different formats and can be used to search a single context or a named Context (or object). The name, in either case, is generally the name of the DirContext to search—in some cases this is also specified as the "DirContext or Object" to search. We use these methods to search within the LDAP server. In one case we specify the object to search for, by passing in a string that identifies a given DN in the LDAP server. The sample program's `displayByName()` method demonstrates an easy and typical search using JNDI and LDAP (and a style you will see in the few books that touch on the subject). The method uses the InitialDirContext object's (the initCtx variable) `search()` method. You can search from any DirContext using the Name parameter (or a string, typically) to identify on which Context or object to search. An empty string specifies the existing Context as the root of the search and all searches are relative to that Context.

`displayByName()` is a method in our sample code that demonstrates a search using a filter and SearchControls object. This particular version of



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Listing 4 Calling All Methods initCtx.createSubcontext(dn, attributes) is the call to create the entry in LDAP. The createDeviceEntry() method also, if necessary, calls addEntryToGroup() to add the new entry's DN to its chosen group.

```
Attributes attrs = initCtx.getAttributes(group);
. . .
Attribute attr = attrs.get("uniquemember");
if (attr == null)
  attr = new BasicAttribute("uniquemember");

if (!attr.contains(dn))
{
  attr.add(dn);
  ModificationItem mi =
    new ModificationItem(
    DirContext.REPLACE_ATTRIBUTE, attr);
  ModificationItem[] mis = { mi };

  initCtx.modifyAttributes(group, mis);
}
```

`search()` allows a greater degree of control for the search. The code from this method is as follows:

```
String filter =
  "(objectclass=netdevice)";
SearchControls sc =
  new SearchControls();
sc.setSearchScope(
  SearchControls.SUBTREE_SCOPE);
sc.setReturningObjFlag(false);
try
{
  NamingEnumeration enumDev =
    initCtx.search(BASE, filter, sc);
```

First we set up a filter string. This filter is an LDAP-style filter that means "search for all the entries where the entry contains an object class attribute with a value of 'netdevice.'" Our device entries are all entries of type "netdevice" so this is our way of filtering out just our device entries from all of the other entries in the directory server.

Next we create a SearchControls object. SearchControls allows a series of options to be set that will place constraints on the search and modify the items returned by the search. In this case, we specify two items for our search: a search scope and a returning object flag. `setSearchScope()` sets the scope of the search, SUBTREE_SCOPE, which means that our search will encompass the named context or object we specify and everything beneath it. In our case, we will search the entire domain since we're starting at o=rapidlogic.com.

The second method we specify is `setReturningObjectFlag()` which sets a parameter instructing the search to return either just the name and class, along with any Attributes, or the name, class, attributes and the object instance bound to the context (as discussed in the previous "Initializing JNDI, Context, and DirContext" section).

One thing that may be obvious is if the `search()` (or `listBindings()` of Context) method has to return a set of bound objects from the server, as opposed to just the name and class associations, it will cause more overhead and will take much longer to perform the operation. This is a performance issue to consider when doing lists and searches (or lookups) with JNDI. For that reason, we use SearchControls to put a constraint on the search. In this case, we want our search to return only the names and classes for the entries, but not the objects bound to the names. SearchControls also allows us to specify a set of attributes that we want returned for each entry searched. The sample program's `displayByOUs()` and `displayByGroups()` methods show how to specify the returned attributes. This instructs `search()` to return an enumeration of SearchResult objects (more information on the SearchResult class is presented later) that contain only the Attributes you specified. Therefore if only the "cn=" and "ou=" attributes of the entries found in a search are wanted, they would be specified in the SearchControls. Other aspects of SearchControls can be found in the JNDI documentation.

Finally we call `search()`. The string passed in as the first parameter specifies the object from which to perform the search. In this case the string specifies the name of the suffix of our sample database entries in the LDAP server, "o=rapidlogic.com."

Attributes

The section of code shown in Listing 2 uses the returned enumeration of SearchResult objects to obtain the associated attributes for each of the SearchResult objects. Recall that each SearchResult in the NamingEnumeration represents a single entry returned from the `search()`. (The associated JTree code has been left out of Listing 2 for clarity.)

The code loops through the NamingEnumeration returned by the `search()`. It extracts each SearchResult element, and from this it obtains its associated list of Attributes with a call to `getAttributes()`. Attributes is an interface used to represent a set of Attribute types. Attributes and Attribute (don't get the two confused) are interfaces that have two base implementations in the BasicAttributes and BasicAttribute classes. Attribute represents an ID associated with single or multiple values. In the case of LDAP, the Attribute ID will represent an LDAP attribute that makes up a device entry, such as "ou," "cn," "objectclass," etc. The values associated with Attribute ID will be the actual values of the entry, such as "netdevice" (for the "objectclass" attribute) or "Workstation for James" (for the "cn" attribute). In cases where the LDAP attribute has multiple values, these values will all be returned when you request the values for a given Attribute ID. (You iterate through the NamingEnumeration returned by the Attribute method `getAll()` to find each of the values when multiple values are associated with a given Attribute.)

In our code listing, we obtain a NamingEnumeration from each of the Attributes we extract from a SearchResult. The NamingEnumeration will contain a set of objects that implement the Attribute interface. (Remember, Attribute is an interface—we cast to this, but the Enumeration actually contains BasicAttribute objects or some other object that implements the Attribute interface, with an implementation provided by the SPI.) We loop through each Attribute, extracting its ID and its set of values. This is the information that will be used to create the JTree hierarchy.

Creating Devices

To add an LDAP entry for a device, the console uses a separate dialog (see Figure 2). The user fills in the dialog with all the attribute values for an entry of type objectclass=netdevice, and presses the OK button. The dialog creates a BasicAttributes object from the data entered into the fields of the dialog and uses the initial Context to create the entry shown in Listing 3.

The sample code's `createDeviceEntry()` method also, if necessary, calls its `addEntryToGroup()` method to add the new entry's DN to its chosen group. The relevant lines of code are shown in Listing 4.

The Attributes for the group are retrieved from the LDAP server, and then the DN of the new entry is added to the group's "uniquemember" attribute. A ModificationItem is created, and the LDAP server is then modified by calling `initCtx.modifyAttributes()`, passing it the group's DN and the ModificationItem.

Deleting Devices

To delete the LDAP entry for a device, the console grabs the DN from the tree node and simply calls `unbind()`, passing in the DN on the initial Context. The remove function also modifies the group entries, exactly like the add operation, to remove the entry's reference in the groups.

Device Control

The user schema files provided as part of this article contain specific information to handle serialization of Java Objects. This schema is defined by Sun to support the LDAP SPI and it al-

lows Java objects to be bound to LDAP entries using the `bind()` method of JNDI's Context (and through inheritance, DirContext).

This binding is performed by the SPI, which serializes the object, converts it to base 64, and enters it as an attribute, along with other identifying attributes, into the entry to which it is being bound.

In our example, we use this functionality to store instances of our Applet Device Customizers. Each customizer represents a communication interface to one of the devices whose information is stored in the LDAP server. For example, when a printer is chosen in the JTree, the right window displays an interface to the chosen printer. Optimally, this interface would retrieve certain information (the mostly static information) from the JTree (which came from the LDAP server). It would also connect to the chosen printer, retrieve the more dynamic information, and display all that information at once. The interface would also allow a user to interact with the device; for example, to print to a printer, or send fax information to a fax machine.

Our example has a few dummy Applet Device Customizers that are created and displayed when a device is selected in the JTree. The object instance is then bound to the LDAP directory, to the DN of its device. The code that interacts with the LDAP server is very simple:

```
obj = ctx.lookup(dn);
if (!(obj instanceof JApplet))
{
  // create applet
  . . .
  ctx.rebind(
    dn, obj, ctx.getAttributes(dn));
}
```

`lookup()` is used to retrieve the object bound to the chosen DN. If the retrieved object is not a JApplet, then one is created and the DN's entry is recreated with a new binding that includes the JApplet. If it is a JApplet, then we use that instance so that we do not need to recreate any of the state information for the JApplet.

Both JNDI and LDAP hold great potential for easing distributed application building, especially when applied together—our example demonstrates how this is true when dealing with devices. Sun has gone to great lengths to make JNDI a very abstract and simple API for working with many different types of naming and directory services. This goes a long way toward simplifying the lives of developers when they have to deal with many different services. LDAP also provides a standard mechanism in the enterprise for the storage of common sets of data for quick, read-oriented access. It is especially useful as a central point for storing this information, as in our examples, when dealing with large groups of heterogeneous devices and their associated data and metadata. Using JNDI and LDAP together, you can create a centralized "white pages" that contains information on a myriad of heterogeneous devices. You can use a single API to browse, search, and modify the information, and you can bind simple customizer objects to access and control these devices. ■

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The Code Fragment Container

Organize your example code and templates into a departmental resource

by Robert Flenner

> *Example isn't another way to teach, it is the only way to teach.*
> —*Albert Einstein*

The words of Albert Einstein reflect the reality of how we go about learning. We learn by example. In programming we learn by copying code from templates, books, and so forth. Who hasn't taken an example, modified it, and created a new software entity from "scratch?" It's the basic way we teach and learn—by example.

Every programmer has seen how easy it is to create a code example to display "Hello World" on a computer screen:

```
class HelloWorldApp {
  public static void main(String[] args) {

//Display the string.
System.out.println("Hello World!");
  }
}
```

This is the first code that most programmers copy and run. Its usage continues because it's simple and it provides immediate feedback. This code presents a complete application; however, the more advanced Java programmer may consider it a code fragment that provides an example for the Java novice.

While examples and code fragments are often used in projects, development methodologies don't address the significance or the impact of this practice. With object oriented methodologies, a considerable amount of time is spent describing the iterative nature of the development process. Evolving software artifacts through an iterative process can be difficult, error prone, and costly.

Bringing discipline to the common practice of copying code will result in a more productive technique for learning and developing software. In this article, I will discuss a Code Fragment Container (CFC) tool that helps minimize the errors that can be introduced between the design, construction, and testing phases of a project. It can also provide a basis for improving the software learning process and coping with the rapid change of the Java development environment.

Using Code Fragments

A code fragment is a ready-to-use, but often unfinished portion of code that provides an example or template for programming. It is carefully selected to improve the understanding of a critical software concept or idiom. Fragments contain as few lines of code as required to teach the concept effectively. Most fragments in Java will evolve into new class methods or augment existing class behavior. So why not just create the methods for a class as opposed to fragments?

First of all, you may not have the time necessary to develop the full component. This will be the case when learning new features and extending existing skills and knowledge. The fragment captures only that which is of value to your current learning. It is an example that is worth saving and will be reused at a later point in time.

Second, you may not have the experience level with the language or problem to determine object model responsibilities and collaborations. Defining object models is an iterative process. Most objects mature and are refined as the development progresses. Avoiding class explosion early in the process may help simplify the model until clearer lines of required responsibilities and collaborations surface.

And third, you just may not understand the problem well enough yet to define an adequate solution.

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Stop Copying, Start Saving Fragments

Copying code from various sources and making modifications is a common practice, yet it has little discipline. Many programmers copy code into their favorite IDE and begin modifying it to satisfy some requirement. By establishing a process and a simple tool such as a CFC you can enjoy a number of benefits over simply copying:

A CFC can provide a tool or aid to learning Java. Fragments can help to highlight new areas of interest, development, and exploration.

A CFC can assist in coping with rapid Java/JDK change. Java and the JDK are evolving at a pace that is making it difficult for programmers to keep abreast of the changes and facilities that are available. New packages, new components, and new tools are being released almost daily. Complex changes in configuration and installation can absorb a considerable amount of time. Keeping your development in a simpler environment can have substantial benefits, especially for new developers.

A CFC can help to maintain a repository of code. This can assist in searching and finding code that is meaningful for future projects. It can help to provide an audit trail for code that has been used in past projects.

A CFC can improve reliability. The repository contains code that has already been tested and proven in other projects. Although it is not complete within the fragment context, over time the code fragment will be proven for the results that are expected.

A CFC can improve testing and tuning. The CFC can improve unit-testing capabilities by isolating code from the supporting environment and provide a platform for benchmarking.

Once you build the CFC, you'll want to start populating it with code fragments. However, use discretion in your selection—not all code fragments will benefit from being placed in the CFC. Select code that is repetitive but always requires "tweaking," or code that is required but not easily remembered. Any code that is fundamental to a design pattern and tends to "glue" the pieces together is a good candidate, as is code that is new to you. Another useful criterion is code that changes significantly between releases.

Listing 1 Fragment Definition Format The Fragment Definition Format (FDF) provides an XML format for describing and exchanging code fragments.

```
/*<FRAGMENT name="rdf.jworkspace.kit" category="SwingText"
  href="http://www.java-pro.com"><!--*/

/******     Insert fragment code here    ******/

/*--></FRAGMENT>*/

name = unique identifier
category = desired classification of fragment
href = description and/or tuturial information reference

not shown: keyword = element to enable associative look-up
```

Once you have selected some code, bring the code into the CFC and build the required source to enable compiling and testing. In the fragment comments, document any assumptions about and constraints in using the code. Document the origin or source of the code. Then, try to classify the code in terms of component usage, services provided, business application, or place of origin.

Most IDEs still have not recognized the potential of the Internet in the development process

The requirements for a Code Fragment Container (CFC) are very similar to a simple IDE. It must easily integrate into current development environments, and it must provide basic text editing capabilities (edit, copy, and paste functions). It must provide the ability to compile and execute programs containing fragments and allow classification of fragments and documentation. It has to provide navigation capabilities and

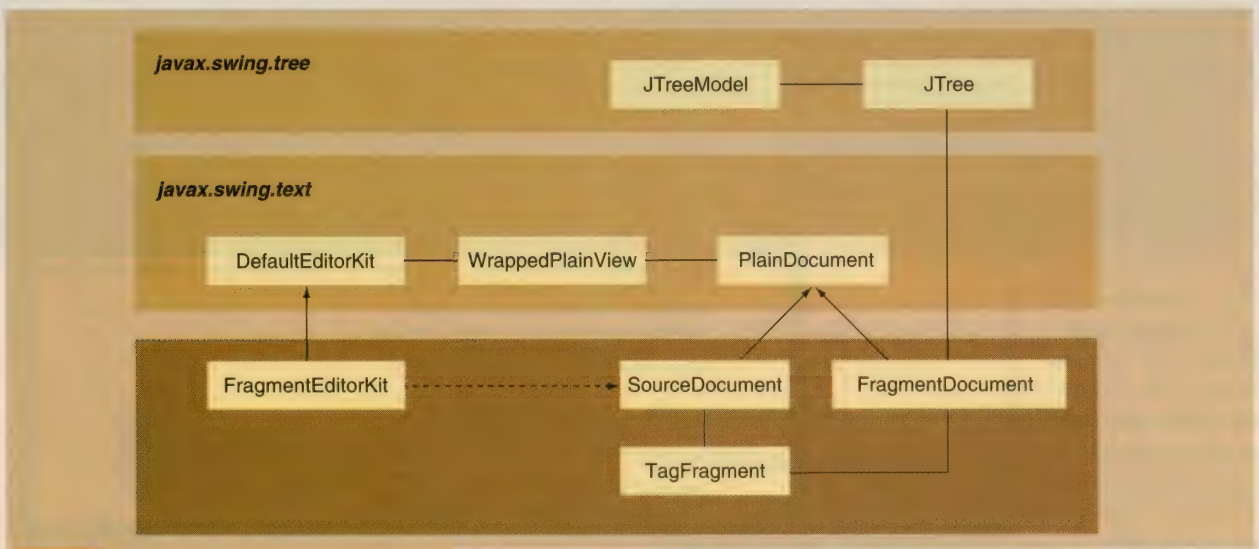

Figure 1 Code Fragment Container Classes With the javax.swing.text package, you can create powerful editing tools. The key is in understanding the relationships between the many classes and interfaces that are defined. With that knowledge, the resulting coding effort can be minimal.

Listing 2 FragmentEditorKit This is an example of the minimum requirements for an editor kit. An editor kit ties together the components necessary to create, edit, and view information. The javax.swing.text package contains the DefaultEditorKit which is used with JEditorPane. There are also style, HTML, and RTF kits available. The JWorkSpace application, which uses a CFC, actually extends JavaEditorKit to provide Java token recognition and colorizing as is visible in the screen shots.

```
import java.io.*;
import javax.swing.*;
import javax.swing.text.*;
import javax.swing.tree.*;

public class FragmentEditorKit extends DefaultEditorKit {

    public FragmentEditorKit() {
      super();
    }
  /*<FRAGMENT> name="ref.jworkspace.kit"
  category="SwingText"
    href="http://www.java-pro.com">*/<!--/*
    The following methods are typical for a simple user
    defined editor kit

    The MIME type of the data that this kit supports
    */

    public String getContentType() {
      return "text/java";
    }

    // Provide an easy way to replicate the kit
    public Object clone() {
      FragmentEditorKit kit = new FragmentEditorKit();
      return kit;
    }

    // Create the Fragment Document interface
    public Document createDefaultDocument() {
      return new FragmentDocument();
    }

    // Typically overidden to parse input
    public void read(Reader in, Document doc, int pos)
      throws IOException, BadLocationException {
      super.read(in, doc, pos);
    }

    // The factory responsible for creating the view to
    // the source code fragments
    public final ViewFactory getViewFactory() {
      return new FragmentFactory();
    }

    // The view(s)the factory will create
    public class FragmentFactory implements ViewFactory {
      public View create(Element element) {
        return fragmentView = new FragmentView(element);
      }
    }

/*<--</FRAGMENT>*/
```

allow you to store and retrieve fragments. You should be able to mark and unmark fragment code, and it must allow you to import fragments into higher level IDEs and wizard tools.

Building the CFC

Figure 1 shows the primary classes of the CFC. We will integrate our CFC into existing development environments by simply creating fragment tags within source code comments and source code within XML comments (see Listing 1). This will trigger the identification of fragment code within the container and will allow the code to function in any IDE that processes Java code. It will also allow XML parsers to validate the simple data definition. This enables a powerful capability within existing development tools. Let's take a closer look at these CFC building blocks.

FragmentEditorKit Listing 2 shows the `FragmentEditorKit` class as an example of extending the DefaultEditorKit class. Figure 2 shows how a JEditorPane can be used to display the project components selected by the nodes of the JTree control. This is similar to the navigation and selection used in most commercial IDEs today. The JEditorPane will give us standard text editing capabilities. We will extend DefaultEditorKit to pull the components (View/Document/Actions) together and enable the SourceDocument class to be associated with the "text/java" MIME type. The code fragment in Listing 3 creates and registers the editor kit with the target JEditorPane.

The editor kit will allow us to associate documents with views and, more specifically, views with concrete document elements. The Element is an important interface in the Swing text model.

SourceDocument A Document is composed of one or more Elements. The document content has many associated views that can be used without changing the underlying document model. This is especially important for the Code Fragment Container. For the tool to be useful, it must easily fit into the Java source structure of wrapping text lines. The `SourceDocument` class extends PlainDocument which associates a line (wrapped or not) with a single element.

The `SourceDocument` class will create `Position` objects that track the location of fragments identified within the source code. Fragments will be identified by <FRAGMENT> tags and will be terminated by a corresponding </FRAG-

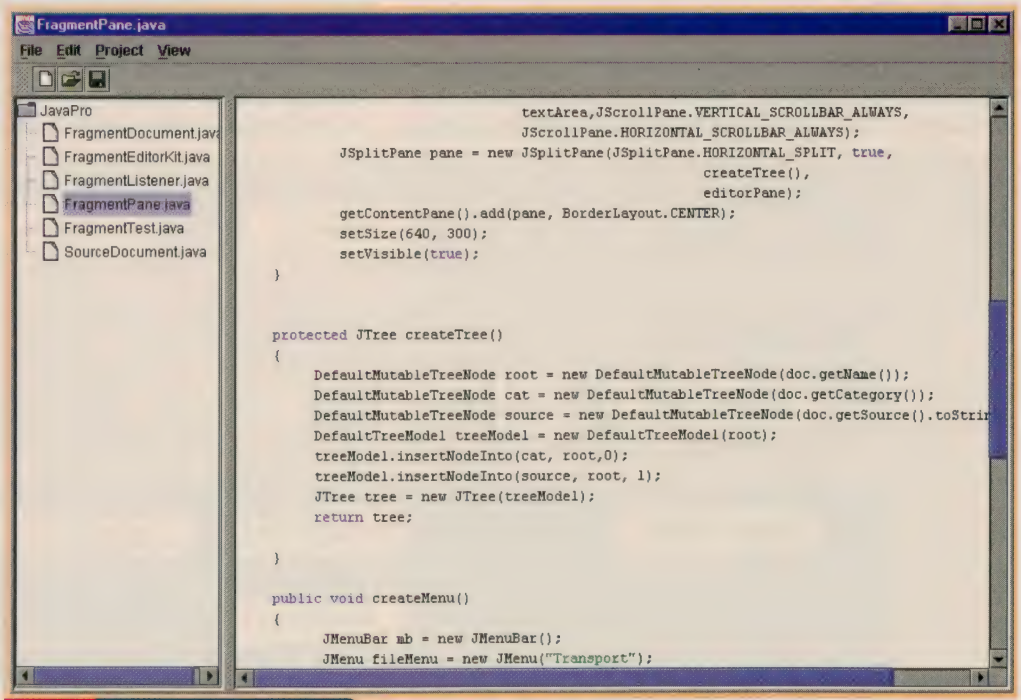

Figure 2 Navigating and Selecting A JEditorPane will be used to display the project components selected by the nodes of the JTree control. This is similar to the navigation and selection used in most commercial IDEs today.

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Listing 3 Register Your Kit This code registers the FragmentEditorKit from Listing 2 with the target JEditorPane.

```
/*<FRAGMENT> name="ref.jworkspace.kit.create"
category="Text" href="http://www.java-pro.com">*/<!--/*
Initializes and registers an editor kit with a text
editor...used in Fragment Container<--</FRAGMENT>*/

protected DefaultEditorKit createEditorKit()
{
  // textArea references a JEditorPane
  DefaultEditorKit kit = new FragmentEditorKit();
  textArea.setEditorKitForContentType("text/java", kit);
  textArea.setContentType("text/java");
  textArea.setBackground(Color.white);
  textArea.setFont(new Font("Courier", 0, 12));
  textArea.setEditable(true);

  // This kit uses JavaContext (styles/veiw) from the Sun
  // JavaEditorKit
  JavaContext styles =
    ((FragmentEditorKit)kit).getStylePreferences();
  Style s;
  s = styles.getStyleForScanValue(
    Token.COMMENT.getScanValue());
  StyleConstants.setForeground(s, new Color(102, 153, 153));
  s = styles.getStyleForScanValue(
    Token.STRINGVAL.getScanValue());
  StyleConstants.setForeground(s, new Color(102, 153, 102));
  Color keyword = new Color(102, 102, 255);
  for (int code = 70; code <= 130; code++) {
    s = styles.getStyleForScanValue(code);
    if (s != null) {
      StyleConstants.setForeground(s, keyword);
    }
  }
  return kit;
}
```

Listing 4 Processing the Events The insertUpdate() method of SourceDocument is used to process the document change events.

```
public void insertUpdate(DefaultDocumentEvent chng,
  AttributeSet attr)
{
  // notify super class of update
  super.insertUpdate(chng, attr);
  DocumentEvent.ElementChange ec =
    chng.getChange(getDefaultRootElement());
  if (ec != null) {

// ec will be non-null when a line has been added to
// the document
    Element[] added = ec.getChildrenRemoved();
    for(int i=0; i<added.length; i++) {
      Element elem = added[i];
      int p0 = elem.getStartOffset();
      int p1 = elem.getEndOffset();
      String s;
      try {
        s = getText(p0, p1 - p0);
        int index = s.indexOf(FRAGMENT_TAG_START);

        // for each line added scan text for fragment tags

        if (index >= 0) {
          inFragment = true;
          int start = elem.getStartOffset()+index;

          // create marker if start of fragment and no
          // marker currently exists

          if(!containsMarker(start)) {
            createMarker(start);
          }
        }
        // now check same line for end tag
        index = s.indexOf(FRAGMENT_TAG_END);
        if (index >= 0) {
          inFragment = false;
          int end =
            elem.getStartOffset()+index+FRAGMENT_END_TAGL;

          // update the marker to indicate source contains
          // fragment and fire fragment event
          updateMarker(end);
        }
      } catch (BadLocationException e) {}
    }
  }
}
```

MENT> tag. Fragment tags will only be significant within enclosing Java comment tags /* and *. The Position objects are maintained by the `AbstractDocument` class. Therefore as the source code is edited and the tags are moved within the document, no coding is required to maintain the positions. The `insertUpdate()` method of `SourceDocument`, shown in Listing 4, is used to process the document change events.

An inner class of `SourceDocument`, `TagFragment`, will be used to manage and hold the fragment positions. This class acts as a helper class to `SourceDocument` and it creates fragment documents. When `SourceDocument` fires an `insertFragmentEvent()`, `TagFragment` will be wrapped in the event notification. All listeners of fragment events can determine the changes required to models and views based on `TagFragment` (see Listing 5).

FragmentDocument The </FRAGMENT> end tag indicates that a `FragmentDocument` object can be created. `FragmentDocument` also extends PlainDocument and becomes a "listener" for `SourceDocument` events. As text is inserted into the source document editor, `FragmentDocument` is notified and it will translate and update its document structure if the inserted text is within the bounds of its parent fragment (see Listing 6).

`FragmentDocument` uses an XML parser to validate the document structure. However, a simpler parser could be used. The defined attributes allow for unique naming, classifying, and providing a direct reference to help information. Support for authorship, versioning, and keyword associative look-up using JavaSpaces and JINI technologies is currently in development. An "href" attribute indicates the origin of the fragment (for example, see the first line of Listing 1). If selected, the CFC will fetch the corresponding URL. Figure 3 shows how you can call the *Java Pro* Web site using the "href" attribute tag. This provides a powerful capability of linking fragments with networked systems to enable a more structured learning experience.

We will use JTree (the Fragment Tree) as the user interface control to display a hierarchical view of the code fragments. This will allow us to easily navigate through the fragments of the project. We will also include hyperlink capabilities so that fragments can be accessed locally or over the Internet.

Code similar to the `createTree()` method in the `FragmentPane` class in Listing 7 is so common that it becomes a candidate for a simple JTreeModel fragment. The code fragment initializes the static labels for a tree structure. You might consider a few improvements such as dynamic initialization from a persistent model, or node creation from user input. Once you understand and recognize commonality in code structures, look for opportunities to create classes or extend existing classes and move the code fragment into a more robust development environment.

Bringing Order Through Classification

The container for source code fragments allows you to classify them according to their usage in a software project. Of course, the classification of fragments can be as varied as the develop-

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101 ❑ Finance, banking, accounting, insurance
102 ❑ Manufacturing other than computer hardware and software
103 ❑ Manufacturing computers and computer software
104 ❑ Non-computer retailer, distributor, wholesaler
105 ❑ Applications software development
106 ❑ Aerospace
107 ❑ Government, military
108 ❑ Agriculture, mining, construction, oil & gas
109 ❑ Transportation, utilities
110 ❑ Media, marketing, advertising
111 ❑ Real estate
112 ❑ Research and development
113 ❑ Engineering
114 ❑ VAR/Systems Integrators
115 ❑ Communications services
116 ❑ Computer-related retailer, distributor, wholesaler
117 ❑ Systems software development
118 ❑ Education
119 ❑ Health, medical, legal
120 ❑ Consulting (please specify)

199 ❑ Other (please specify)

2. WHAT IS YOUR CURRENT JOB TITLE? (SELECT ONLY ONE FROM THE FOLLOWING SIX (6) CATEGORIES):

Application development manager/architect:
201 ❑ Applications development manager
202 ❑ Software development director
203 ❑ Software architect
204 ❑ Software project leader
205 ❑ Project manager
206 ❑ Advanced technology evaluator
207 ❑ Software team leader
208 ❑ Software engineering supervisor
209 ❑ Systems analyst/designer
210 ❑ Database designer
211 ❑ Application manager/ administrator
295 ❑ Other (please specify)

IS manager:
230 ❑ CIO, Technical VP
231 ❑ IS/MIS manager
296 ❑ Other (please specify)

Application developer:
240 ❑ Applications developer/programmer
297 ❑ Other (please specify)

Computer operations staff:
250 ❑ System Administrator
251 ❑ LAN Administrator
252 ❑ Help Desk
298 ❑ Other (please specify)

Corporate manager:
260 ❑ CEO, president, partner, chairman, owner
261 ❑ VP, controller, director of marketing/sales, General manager, division/department head

Other (categories not listed above):
299 ❑ Other (please specify)

3. ARE YOU DEVELOPING APPLICATIONS THAT INVOLVE WINDOWS NT/2000 OR DO YOU PLAN TO BE IN THE NEXT 12 MONTHS?

301 ❑ Yes 302 ❑ No

4. ARE YOU DEVELOPING APPLICATIONS THAT WILL INVOLVE ONE OR MORE SERVERS OR HOSTS OR DO YOU PLAN TO BE IN THE NEXT 12 MONTHS?

401 ❑ Yes 402 ❑ No

5. DO YOU EVALUATE, SPECIFY, RECOMMEND, AUTHORIZE, OR APPROVE THE PURCHASE OF (PLEASE CHECK ALL THAT APPLY):

501 ❑ Application development tools?
502 ❑ Database products?
503 ❑ Internet and/or Intranet products?
504 ❑ Middleware products?
505 ❑ Hardware servers?
506 ❑ Modeling tools
507 ❑ Testing/QA tools
508 ❑ Software process tools (Project/Process Management, Metrics, CM, etc.)
599 ❑ None of the above

6. WHICH OF THE FOLLOWING SOFTWARE SERVERS DO YOU BUY, SPECIFY, RECOMMEND, OR APPROVE THE PURCHASE OF AND/OR CURRENTLY HAVE INSTALLED AT THIS LOCATION (PLEASE CHECK ALL THAT APPLY):

	Buy, Specify, Recommend, Approve	Installed
Web	601 ❑	602 ❑
Database	603 ❑	604 ❑
Application	605 ❑	606 ❑
Transaction	607 ❑	608 ❑
E-mail	609 ❑	610 ❑
Imaging	611 ❑	612 ❑
Commerce	613 ❑	614 ❑
Remote Access	615 ❑	616 ❑
Communication/SNA	617 ❑	618 ❑

699 ❑ None of the above

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7. SERVER/HOST OPERATING SYSTEMS IN USE AT THIS ENTIRE LOCATION (PLEASE CHECK ALL THAT APPLY):

701 ❑ Windows NT/2000 Server
702 ❑ Unix (all flavors)
703 ❑ Netware/Intranetware
704 ❑ OS/400
705 ❑ VMS
706 ❑ MVS/VM
707 ❑ OS/2
799 ❑ Other (please specify)

---

8. WHAT IS THE ANNUAL DOLLAR VALUE OF COMPUTER PRODUCTS AND SERVICES FOR WHICH YOU ARE PERSONALLY INVOLVED IN THE PURCHASING DECISIONS FOR YOUR ORGANIZATION'S OR LARGEST CLIENT'S INTERNAL USE?

801 ❑ More than $10 million
802 ❑ $5 million - $9,999,999
803 ❑ $2 million - $4,999,999
804 ❑ $1 million - $1,999,999
805 ❑ $500,000 - $999,999
806 ❑ $100,000 - $499,999
807 ❑ $50,000 - $99,999
808 ❑ $10,000 - $49,999
809 ❑ Less than $10,000

9. WHICH OF THE FOLLOWING CATEGORIES OF PRODUCTS DO YOU RECOMMEND, EVALUATE, SPECIFY, BUY, OR APPROVE THE PURCHASE OF? (CHECK ALL THAT APPLY):

901 ❑ Back office suites
902 ❑ N-Tier Capable Development Tools
903 ❑ ORBs
904 ❑ RPC middleware
905 ❑ Message Oriented Middleware
906 ❑ Application Integration Software
907 ❑ TP Monitors or Transaction Servers
908 ❑ Application Servers
909 ❑ Application Management Software
910 ❑ Component software (VBX, OCX, ActiveX, custom controls, JavaBeans, etc.)
911 ❑ Configuration Management/ Version Control
912 ❑ Project Management Tools
913 ❑ Process Management Tools
914 ❑ Estimation/planning/metrics tools
915 ❑ Class Libraries
916 ❑ Application Frameworks
917 ❑ C/C++ Tools
918 ❑ Java Tools
919 ❑ VB Tools
920 ❑ 4GL Tools
921 ❑ OLAP, Data Mining or Data Warehousing tools
922 ❑ Reporting Tools
923 ❑ Web Authoring Tools
924 ❑ Expert systems/rules engines
925 ❑ Repository
926 ❑ Security Tools/Firewall Software
998 ❑ Other (please specify)

---

999 ❑ None of the above

10. DO YOU RECOMMEND, SPECIFY, APPROVE OR PURCHASE APPLICATION PACKAGES SUCH AS THOSE SOLD BY ORACLE, SAP, PEOPLESOFT, AND BAAN?

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If YES, which types? (Check ALL that apply):

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102 ❑ Human Resources
103 ❑ Sales Automation
104 ❑ Financial/Accounting
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107 ❑ Supply Chain Management
199 ❑ Other (please specify)

---

11. DO YOU RECOMMEND, SPECIFY, APPROVE OR PURCHASE APPLICATION DEVELOPMENT TOOLS FOR CUSTOMIZATION OF AND INTEGRATION WITH ERP OR OTHER APPLICATION PACKAGES?

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ment project itself. The following are examples of various classifications:

Component- or extension-based classification If you are doing user interface development, classifying fragments by components and component events may be beneficial. You may want to align your fragment mapping with your IDE so that components dragged from a component palette have the associated fragment container identified. This helps when you need to develop a quick prototype. You will have easy access to the associated initialization code or templates you find instructive for building components.

Listing 5 Handling Changes When a document change event is generated, and a Position object is created, SourceDocument uses TagFragment to maintain and create fragments. In this respect TagFragment acts as an "artificial" element of the PlainDocument structure.

```
class TagFragment
{
  Position start;
  Position end;
  FragmentDocument doc;
  int index;

  TagFragment(Position start, Position end)
  {
    this.start = start;
    this.end = end;
  }

  public Document getDocument() {
    return SourceDocument.this;
  }

  public FragmentDocument getFragment()
  {
    return doc;
  }
  // An end position triggers the creation of a
  //FragmentDocument
  public void create(Position end)
  {
    this.end = end;
    doc = new FragmentDocument(this);
  }
  // used to determine if a source document listener is
  // impacted by document changes
  public boolean contains(int pos)
  {
    if(pos >= start.getOffset() && pos <= end.getOffset())
      return true;
    else
      return false;
  }

  // determines fragment index within source
  public void setIndex(int index) {
    this.index = index;
  }

  public int getIndex() {
    return index;
  }

  public int getStartOffset() {
    return start.getOffset();
  }

  public int getEndOffset() {
    return end.getOffset();
  }
}
```


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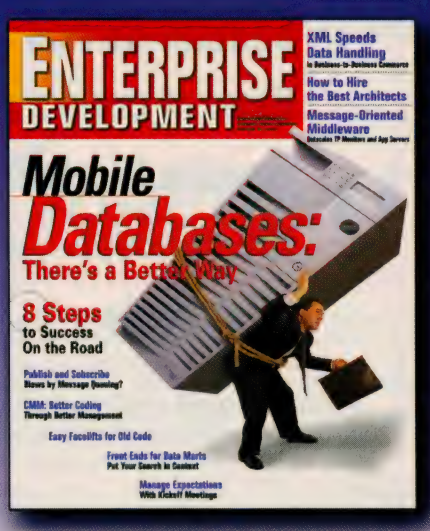

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Listing 6 Tracking Changes When a document change event is generated, FragmentDocument (after already registering as a SourceDocument listener) determines the updates required to synchronize the data models between the source and fragment work spaces.

```
public void insertUpdate(DocumentEvent chng)
{
  int start = chng.getOffset();
  // tag references a SourceDocument inner class that is
  //used as a helper class for fragment position objects
  if(tag.contains(start)) {
    int length = chng.getLength();
    try {
    int translate = start - tag.getStartOffset();
    String s = doc.getText(start,length);
    // call PlainDocument to insert text
    super.insertString(translate,s,null);
    } catch (BadLocationException e) {}
  }
}

public void removeUpdate(DocumentEvent chng) {
  int start = chng.getOffset();
  if(tag.contains(start)) {
    int translate = start - tag.getStartOffset();
      try {
      // call PlainDocument to remove text
        super.remove(translate, chng.getLength());
      } catch (BadLocationException e) {}
  }
}
```

Listing 7 Planting a Tree The Tree initialization (from the FragmentPane code) is so common that it becomes a candidate for a JTree fragment. The code fragment initializes the static labels for a tree structure. In effect, it provides the fragment model for the fragment container.

```
protected JTree createTree()
{
    // doc references a parsed FragmentDocument
    DefaultMutableTreeNode root = new
      DefaultMutableTreeNode(doc.getName());
  DefaultMutableTreeNode cat = new
    DefaultMutableTreeNode(doc.getCategory());
  DefaultMutableTreeNode source = new
    DefaultMutableTreeNode(doc.getSource().toString());
    DefaultTreeModel treeModel = new DefaultTreeModel(root);

    treeModel.insertNodeInto(cat, root,0);
    treeModel.insertNodeInto(source, root, 1);
    JTree tree = new JTree(treeModel);
    return tree;

}
```

Business or department classification A service-based mapping would align fragments with middleware services—for instance, fragments related to integration with CORBA Services, e.g. Naming, Security, Data Access Services, Communication Services, and so on (see Figure 4). If you are developing primarily business logic, it may be appropriate to align the fragment code with business issues and/or requirements. This can be beneficial when working on specific business calculations and can assist in unit testing specific portions of code. Fewer errors will be introduced. Aligning fragments with critical requirements may also assist in providing an audit trail of the code that was brought into the project during design, construction, and testing.

The documentation that is produced is in more of an online format and is in step with the actual design. This helps to maintain the real details of the implementation.

Source reference classification If you spend your time searching through periodicals and books, a reference library may be most beneficial and could easily provide references to Web-site specific information such as tutorials, APIs, and examples.

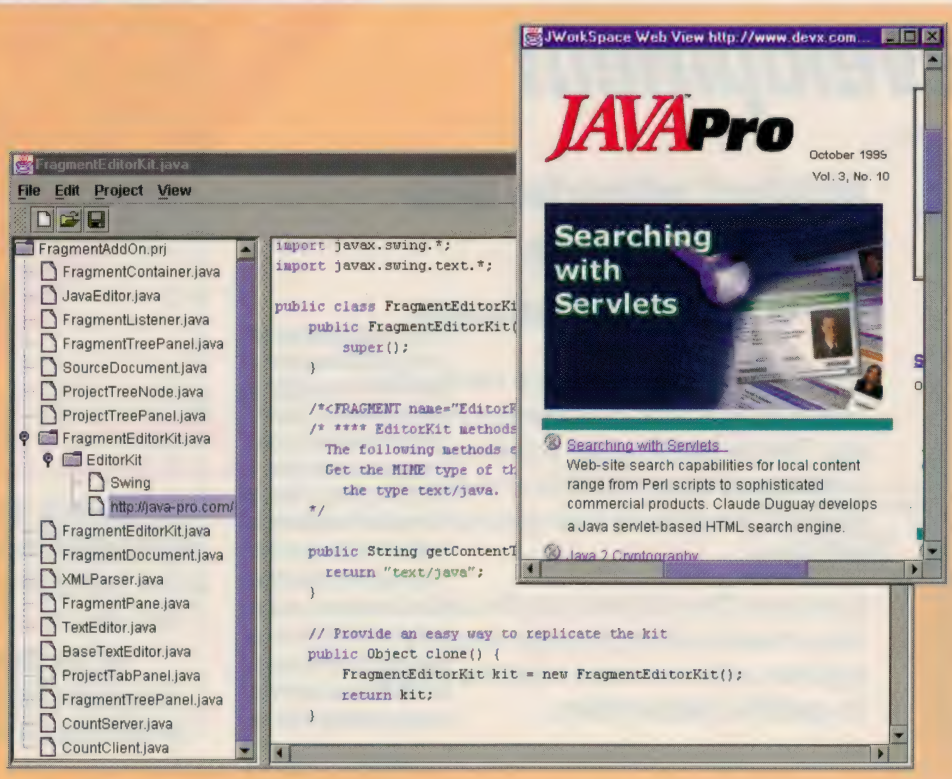

Figure 3 Fetching Web Sites An "href" attribute indicates the origin of the code fragment. If selected, the CFC will fetch the corresponding URL.

Code fragments contain as few lines of code as required to teach the concept effectively

Supporting CFC Framework

Your Code Fragment Container will require a number of additional classes to support the requirements identified earlier in this article. Constructing your application from fragments and

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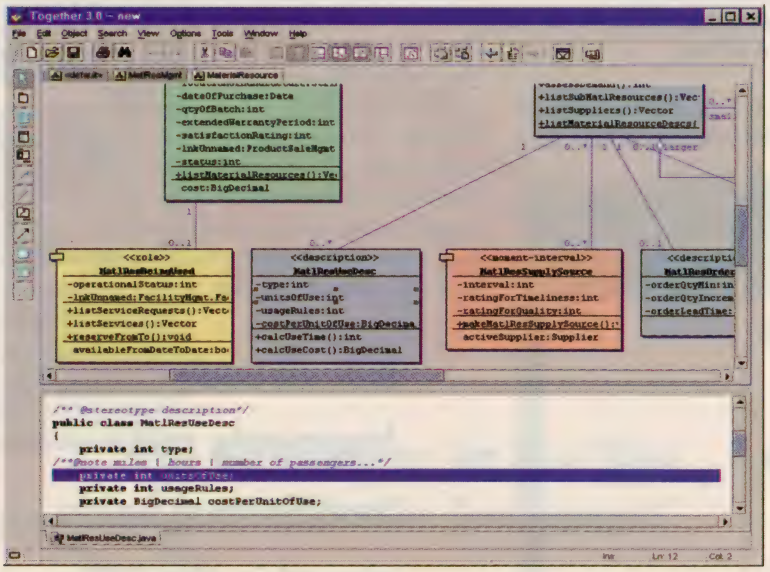

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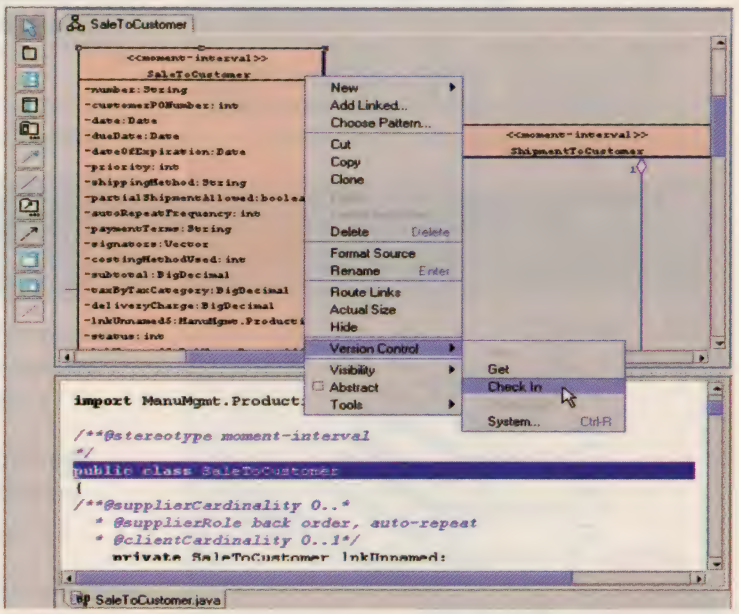

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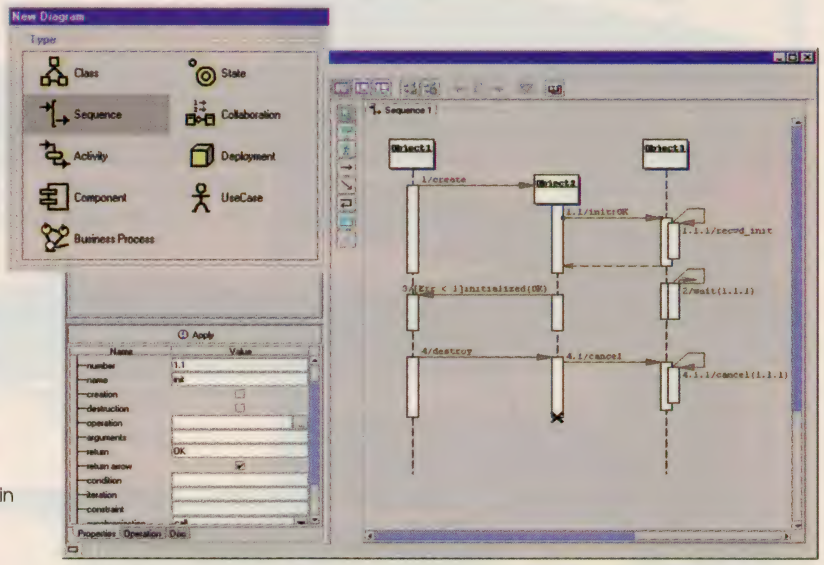

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building it in concert with using it can be a rewarding exercise (see Figure 5). You may consider:

- A ConsolePane object that provides a window to the compiler output, run execution output, error streams, and debugger
- A ProcessWrapper that executes threads to invoke the compiler ("java") and other exec processes such as the Web browser
- A FragmentFilter class to mark and unmark fragments within source code
- A FragmentURL class to associate fragments with Web-site specific information
- A Web based HelpLocator
- An XML Reader and Writer

The JWorkSpace that I am developing will support a JWorkPlace interface for exchanging fragments and open source development material. Technologies such as JINI and JavaSpaces will be used to support the connectivity and dynamic search requirements.

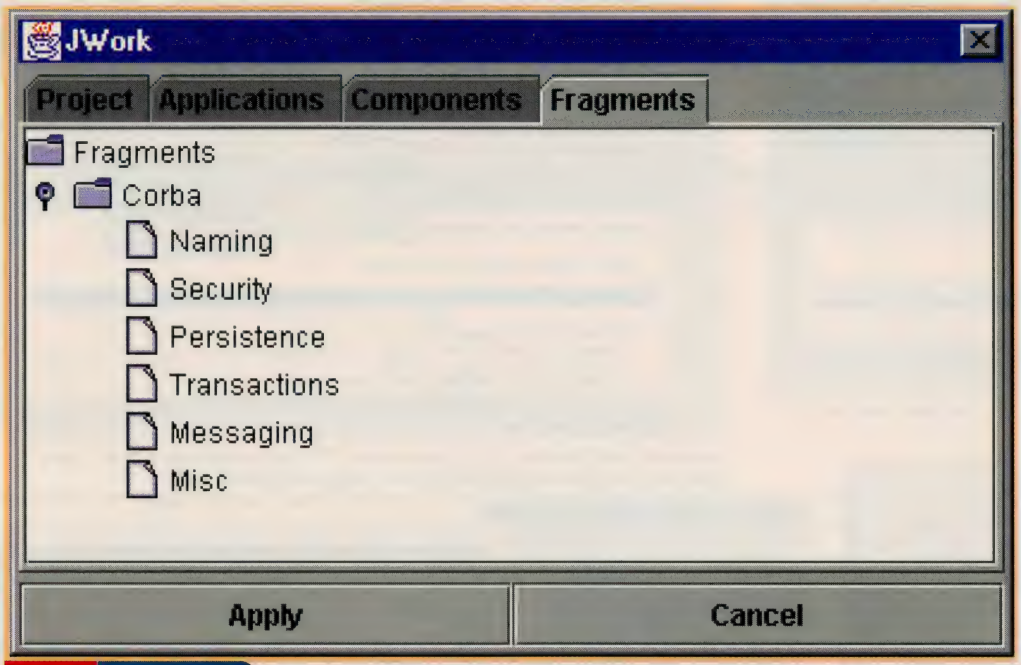

Figure 4 A Group Thing The container for source code fragments allows you to classify them according to their usage in a software project. In this example, a service-based mapping aligns fragments with CORBA services.

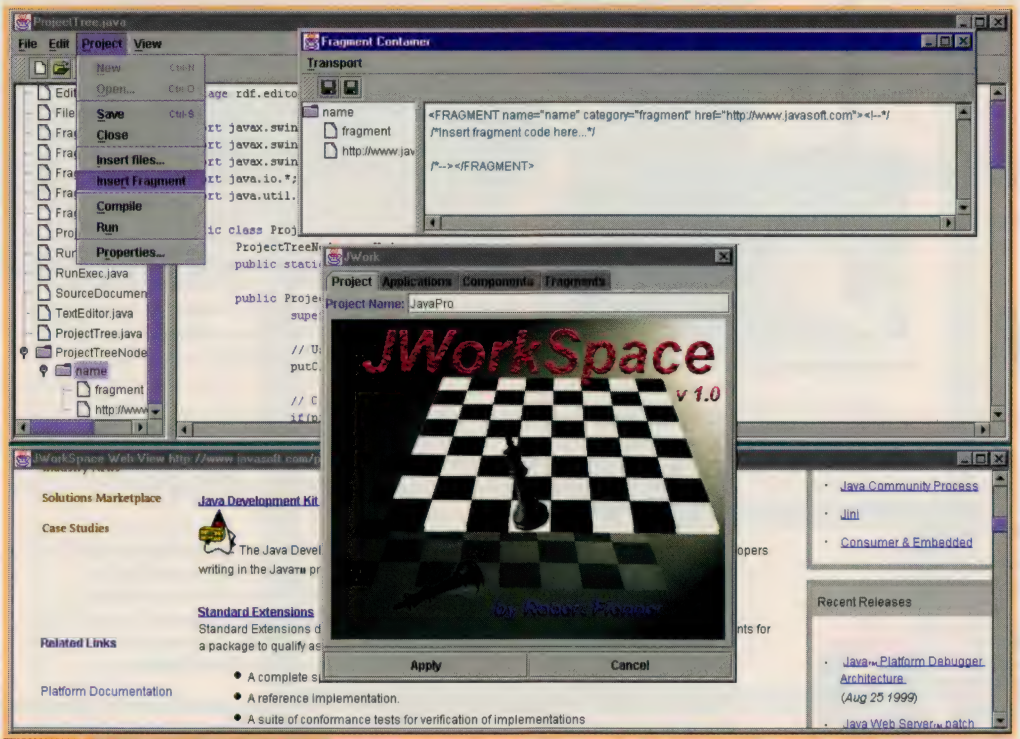

Figure 5 Building a JWorkSpace A Code Fragment Container can evolve. Constructing your application from fragments and building it in concert with using the CFC can be a rewarding exercise.

Distributing and Sharing Fragments

You find many examples of code fragments on software development Web sites such as the Java Developer Connection (JDC) and in magazines such as *Java Pro*. These sites and publications provide a wealth of information on source-code usage. You have more of an opportunity to formalize the content and distribution of source code examples now that most development tools and publications are Web accessible. Java is the perfect language to lead that evolution. In the process, reuse of small (fragment) ideas can be exchanged and can grow into more robust and understandable software solutions.

Not all code fragments will benefit from being placed in the CFC

Most IDEs still have not recognized the potential of the Internet in the development process. It is still difficult to find information or to find the right example to assist with development. Once you do find the right example, it is often difficult to integrate.

As the Open Source movement becomes more commercially viable and mainstream, the companies that recognize the requirements for distributed collaboration and provide the tools necessary to address these requirements will be at a distinct advantage.

Developers have new opportunities for project-development relationships that are only beginning to surface. Having tools and techniques available to assist in distributed development will make you a valuable asset and provide you with access to more rewarding projects. ■

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The Forest and the Trees

It's easy to make a checkbox control in Java if you use the Observer pattern

BY JAMES W. COOPER

A common way for users to choose from a nested list of options in a Windows program is for them to select a checkbox next to each item they are interested in. It was this common visual display that caused me to start thinking about the Java JTree control. I wondered how difficult it would be to implement this design in Java.

The JTree object in the Swing controls is a powerful but simple way of displaying trees of data. A tree is a list of data and subsidiary values that can be represented as indented sub-values of the main value. This can nest to any level of complexity, limited only by the screen real estate you have available to display the information.

A JTree is composed of nodes that may have parents or children. The topmost node, which only has children, is referred to as the *root* node and any node that has no further children is referred to as a *leaf* node.

Like the JList and JTable controls I've discussed in previous columns, the JTree control does not have a scrolling function and therefore needs to be created inside a JScrollPanel:

```
// create interior panel
JPanel jp = new JPanel();
  jp.setLayout(new
    BorderLayout());
  getContentPane().add(jp);

  //create scroll pane
  JScrollPane sp =  new
    JScrollPane();
  jp.add("Center", sp);
```

Each node of the tree implements the TreeNode interface. Since this interface has a number of methods we would otherwise have to implement, it is easiest to start by using or subclassing the `DefaultMutableTreeNode` class to represent the nodes of the tree.

```
//create root node
  root = new
    DefaultMutableTreeNode(
    "Foods");
    //create tree
    tree = new JTree(root);
```

Listing 1 New Nodes After we create the root node of our tree, we add three nodes, each with three leaves.

```
//create 3 nodes, each with three sub nodes
  addNodes("Meats", "Beef", "Chicken", "Pork");
  addNodes("Vegies", "Broccolli", "Carrots", "Peas");
  addNodes("Desserts","Charlotte Russe", "Bananas Flambe",
    "Peach Melba");
//..etc.

//---------------------------------------
    private void addNodes(String b, String n1,
      String n2, String n3) {
      DefaultMutableTreeNode base =
        new DefaultMutableTreeNode(b);
      root.add(base);
      base.add(new DefaultMutableTreeNode(n1));
      base.add(new DefaultMutableTreeNode(n2));
    base.add(new DefaultMutableTreeNode(n3));
    }
```

```
  //add to scroller
  sp.getViewport().add(tree);
```

In this code fragment, you create the root node of the tree. Then, you add three nodes, each with three leaves as shown in Listing 1. Note that you add the first new node to the root and then add each of the remaining nodes to that one.

Figure 1a shows a menu of meats, vegetables, and desserts displayed as a tree. One option in the JTree control is whether the root node is displayed with a "handle," or "+/-" sign indicating that you can expand that node. You can use the `tree.setShowsRootHandles(true)` method to display the handle as shown in Figure 1b. In general, showing this handle is always advisable since the display may otherwise look like a one-element list box.

Selectable Tree Nodes

Now, let's see how you can extend the JTree display to provide those checkboxes so that your users can select one or more nodes. Each cell of the tree needs to be selectable and the class representing that data line needs to remember that you selected it, so it can display the checkbox either checked or unchecked. You accomplish this in Listing 2 by subclassing the DefaultMutableTreeNode to include `setChecked()` and `getChecked()` methods. You can then use these new checkable nodes anywhere you would have used the original nodes, and can ask whether they are checked or not and display the appropriate checkbox state.

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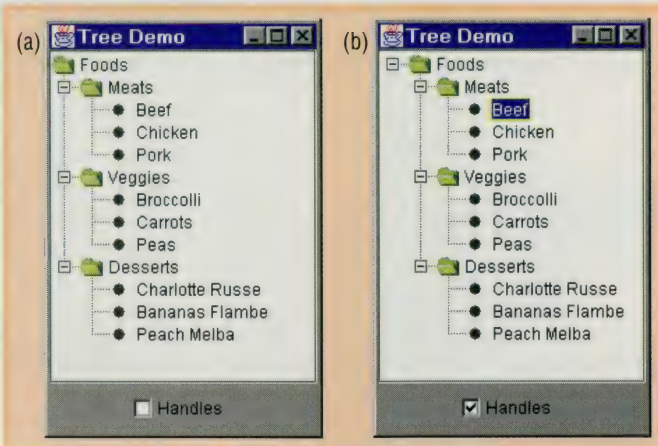

Figure 1 Can You Handle This? A JTree menu display (a) without root handles and (b) with root handles.

Checkboxes in Tree Lists

Like JList and JTable, JTree has a cell renderer that you can subclass or override which will display both text and images. The TreeCellRenderer interface need only implement the one method:

```
getTreeCellRendererComponent(
 JTree tree, Object value,
 boolean selected, boolean expanded,
 boolean leaf, int row, boolean hasFocus)
```

and the DefaultTreeCellRenderer is derived from JLabel. Now, since the JLabel control can display both text and images, you need only obtain copies of the checked and unchecked checkbox images. I obtained them for this example by using PaintShop Pro as a screen image capture program, and selecting a 32 + 32 pixel image of a checked and unchecked box and saving them as checked.gif and unchecked.gif.

Writing a TreeCellRenderer

Writing a complete TreeCellRenderer, like that shown in Listing 3, is incredibly easy. We derive a class from JLabel and change the image and text for each cell of the tree. The `getTreeCellRendererComponent()` method returns that instance with the image and text modified. Thus, this method nearly always ends in

```
return this;  //return current instance
```

Finally, we need to replace the default renderer with this new one:

```
CheckRenderer ckRend = new CheckRenderer();
tree.setCellRenderer(ckRend);
```

The JTree object is a powerful way of displaying trees of data

Listening for the Check Off

Of course, being able to display checkboxes in two states is only useful if the program can listen to whether or not they have been clicked. The JTree has a TreeSelectionListener interface that only needs to implement the `valueChanged()` method. As you can see in Listing 4, each time a tree cell is selected, this listener is called, because you only

Listing 2 Adding Checkboxes If you want checkboxes, each cell of the tree needs to be selectable and the class representing that data line needs to remember that you selected it. You do this by subclassing the DefaultMutableTreeNode to include setChecked() and getChecked() methods.

```
//a tree node that remembers being selected
public class SelectNode
  extends DefaultMutableTreeNode {
  private boolean checked;    //remembers check
  private String text;        //remembers text

    public SelectNode(String label) {
      super(label);
      text = label;
      checked = false;
    }

    public String getText()  {
      return text;
    }
    //can set and get the checked state
    public void setChecked(boolean b) {
      checked = b;
    }
    public boolean getChecked() {
      return checked;
    }
}
```

Listing 3 Rendered Useful This is the complete cell renderer.

```
//cell renderer using check box images
public class CheckRenderer extends JLabel
  implements TreeCellRenderer {
  Color bgray;
  ImageIcon check, uncheck;
  public CheckRenderer() {
    super();
    //read in checkbox icons
    check = new ImageIcon("check.gif");
    uncheck = new ImageIcon("uncheck.gif");
    setHorizontalTextPosition(RIGHT);
  }
  public Component
    getTreeCellRendererComponent(
      JTree tree, Object value, boolean selected,
      boolean expanded,  boolean leaf, int row,
      boolean hasFocus) {
    //get the current node
    SelectNode node = (SelectNode)value;
    //set its text
    setText(node.getText ());
    //set one icon or the other
    if (node.getChecked ())
      setIcon(check);
    else
      setIcon(uncheck);

    return this;  //return this instance
  }
}
```

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need to invert the state of that checkbox state. You figure out which node is selected using the `getLastSelectedPathComponent()` method to find the selected tree cell.

The final program display is shown in Figure 2. This version has a couple of problems, however. First, the selected items are truncated with ellipses. Second, when you click a second time on the checkbox, or anywhere else on that line, it does not deselect the checked line. I was able to figure out why pretty quickly, but I'm not completely sure why the label text changes so elliptically. It may be related to the fact that the images I captured are not exactly the same size: The unchecked is 32+32 but the checked one is 32+30 pixels. However, it is clear that we need to consider some alternative methods for displaying checkboxes.

Another Kind of TreeCellRenderer

I used JLabel for the TreeCellRenderer, but you can actually use any kind of Component you want, as long as it implements the TreeCellRenderer interface. So, why not try using a JCheckBox instead? Surprisingly, you need only change a very few lines of code to do this (Listing 5). Note that I decided to change the background if this cell is currently selected with the mouse. The resulting program is shown in Figure 3.

Now you have removed the label text truncation. You can also see why you have to move to another cell and back again before you can uncheck a line of the display. The "currently selected line" is highlighted in Figure 3, and until you select another line, you

Listing 4 Listening for Nodes Each time a tree cell is selected, TreeSelectionListener is called. We figure out which node is selected using the getLastSelectedPathComponent() method to find the selected tree cell.

```
//Listens for tree selections and
//inverts state of the selected node
public class CheckListener
  implements TreeSelectionListener {
  public void valueChanged(TreeSelectionEvent e) {
    //Get the tree
    JTree tree = (JTree)e.getSource ();

    //get the specific node
    SelectNode node = (SelectNode)
      tree.getLastSelectedPathComponent ();

    //change its check state
    if (node.getChecked ())
      node.setChecked (false);
    else
      node.setChecked (true);
  }
}
```

Listing 5 Switching Components If you want to use the JCheckBox component rather than JLabel for your TreeCellRenderer, you need to make only a few changes to the code.

```
//TreeCellRenderer using a Checkbox
public class CheckRenderer extends JCheckBox
  implements TreeCellRenderer {
    Color bgray;
  public CheckRenderer() {
    super();
    bgray = Color.lightGray;
    bgray = bgray.brighter ();
  }
  public Component getTreeCellRendererComponent (
    JTree tree, Object value, boolean selected,
    boolean expanded, boolean leaf, int row,
    boolean hasFocus) {
    SelectNode node = (SelectNode)value;
    setText(node.getText ());

    //set check box based on whether
    //the node is selected
    setSelected(node.getChecked ());

    //change the background if selected
    if (selected)
      setBackground(bgray);
    else
      setBackground(Color.lightGray );
    return this;
  }
}
```

Listing 6 Changing Listeners To solve this select/deselect problem, change to a mouse listener instead of a selection listener. Then you can respond specifically to each mouse press.

```
//Tree listener for a Mouse Press
public class CheckListener extends MouseAdapter {
  public void mousePressed(MouseEvent e) {
    //get the tree
    JTree tree = (JTree)e.getSource ();
    SelectNode node =
      (SelectNode)tree.getLastSelectedPathComponent ();

    if (node != null) {
      if (node.getChecked ())
        node.setChecked (false);
      else
        node.setChecked (true);

      tree.repaint();
    }
  }
}
```

Listing 7 One Easy Step The TreeNode interface makes it quite easy to write code so that when you check a node of a tree, all of the nodes under it are selected as well.

```
//check or uncheck the current node
//and all of its child nodes
  private void subChecks(SelectNode node, boolean state) {
    node.setChecked (state);    //current node

    //get any child nodes
    Enumeration e = node.children ();
    //call this routine recursively
    //until no more children
    if (e.hasMoreElements ()) {
      while (e.hasMoreElements ()) {
        SelectNode nd = (SelectNode)e.nextElement ();
        subChecks(nd, state);
      }
    } else
      node.setChecked (state); //last node
  }
```

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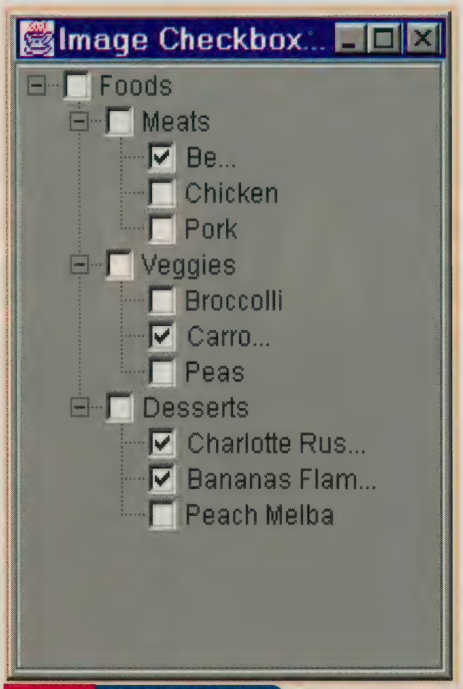

Figure 2 The Final Product This is the final program display using the JLabel component. I changed the background to lightGray so that the three-dimensional effect of the checkboxes is more apparent.

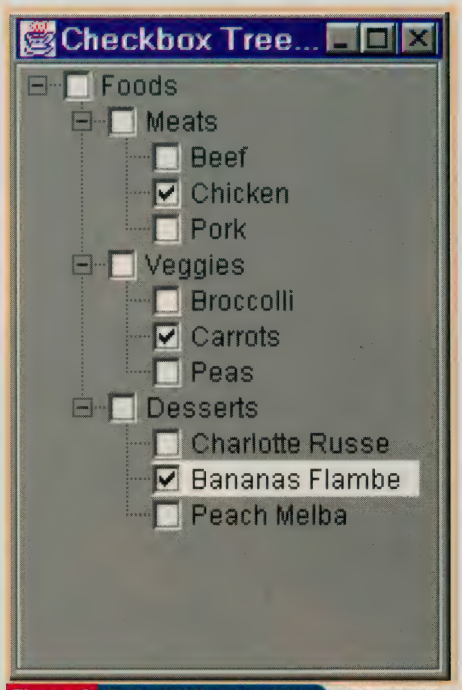

Figure 3 To Put it Another Way This shows the result of tree cell rendering using JCheckBox instead of JLabel.

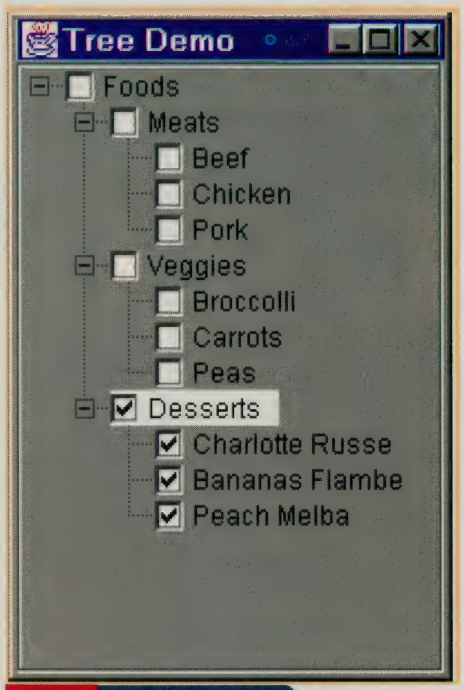

Figure 4 Everything at Once Listing 7 shows how to write code so that when you click on any node, all of its subnodes are selected as well.

TechTIP

Be User-Friendly With Double-Clicks

The idea behind Java's handling of mouse double-clicks is that if the mouse is quickly clicked twice in the same spot, a java.awt.event.MouseEvent event object will be fired to interested parties who have implemented java.awt-.event.MouseListener, and the `getClickCount()` method of this event object, if invoked, will return 2.

Unfortunately, the AWT implementation also relies on fast successive clicks in the same spot. So, if a user of your Java GUI does not click quickly enough, or has trembling hands, or the double-clicks vary in location by a few pixels, the two clicks will probably not be detected.

To avoid this, you can have your code provide its own definition for a double-click, and you can also give the user the capability to modify your definition. The idea is to keep track of the time of mouse events, as well as their locations.

First, have the code of your GUI override public Boolean `mouseUp(java.awt.Event evt, int x, int y)` of the java.awt.Component class. Then, based on the time stamp of two mouse-ups (miliseconds) obtained from java.awt.Event.when long data member, and mouse positions (x and y pixels) between mouse clicks, your code can determine if a double-click has occured or not.

—Behrouz Fallahi

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can't reselect it to uncheck it. Remember your listener is a selection listener rather than a mouse-click listener.

If you change to a mouse listener instead of a selection listener, then you can respond specifically to each mouse press. Listing 6 shows you how to solve the select/deselect problem. The resulting display is unchanged from that in Figure 3. The difference is that clicking twice on a checkbox selects and deselects it.

Checking on the Children

You might decide that whenever you check a node of a tree you want to imply that the nodes under it are all selected as well. This is very simple to accomplish, since the TreeNode interface defines an enumeration of children. Further, you quickly recognize that you mean to select not just all the children in the next lower level but all their children as well to any depth. We can handle this with the simple, recursive routine shown in Listing 7. In our example, this allows us to select all three desserts in a single mouse click and bypass dinner altogether, as shown in Figure 4.

One last note regarding design patterns: All of the listener classes discussed in this column are cases of the Observer pattern. ■

James W. Cooper is a computer science researcher and the author of a number of books in the field. He is currently working on his 13th book, *Java Design Patterns: A Tutorial*, for Addison Wesley Longman.

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Create a JGraph

This lightweight, flexible component makes complex graphing easy

BY CLAUDE DUGUAY

Of the many data structures available to programmers, the graph is one of the best at representing complex relationships between elements. Constructed with nodes and edges, a graph can model anything from transportation between cities to neurons and synapses in the brain. Swing has components for handling lists, trees, tables, and so on, but it has no components that deal with graphs. This month, I'll rectify that by developing a `JGraph` component, complete with customizable models and renderers, and an interface that allows graphs to adjust node positions automatically using pluggable algorithms.

Loose Modeling

To maintain flexibility, we'll use a lot of interfaces in our design (see Figure 1). We can represent a graph with nodes, so we'll need interfaces to make sure we can use custom node and edge elements in our model. The whole model will also use a separate interface to make it possible to create a graph model to suit alternate data requirements. In most cases, you can use the default implementations I provide, but should you need your own, I'll make sure the coupling is as loose as possible and the contract between elements effectively defined.

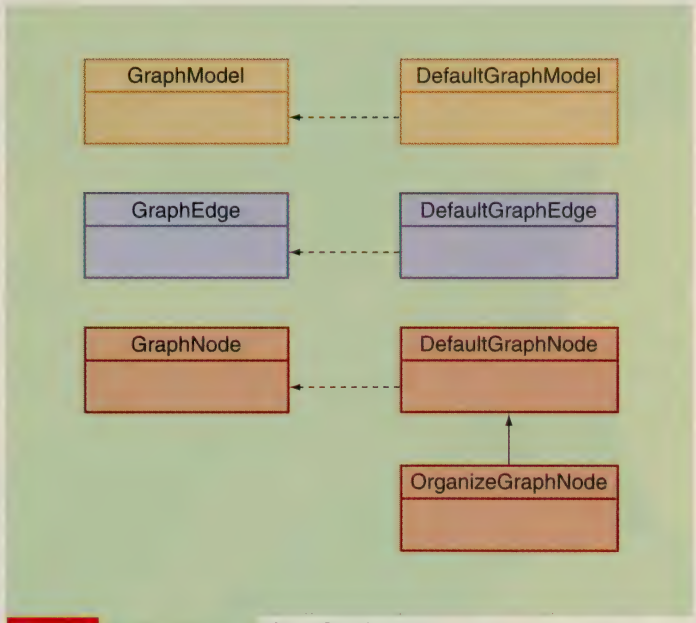

Figure 1 Model Classes Our JGraph component design contains several interfaces for flexibility.

The GraphEdge interface allows us to handle arcs or edges between nodes. We'll identify the nodes at each end of the edge as the "from" and "to" nodes, which we'll access through the `getFrom()` and `getTo()` methods, respectively. We'll also be storing a weight value that describes the stress, or tension, between nodes.

```
public interface GraphEdge
{
   public GraphNode getFrom();
   public GraphNode getTo();
   public double getWeight();
}
```

The GraphNode interface is only slightly more detailed. Each node has a name, a fixed flag that lets us mark it as unmovable, and the *x* and *y* position. We provide read and write accessors for each of these values:

```
public interface GraphNode
{
  public String getName();
  public void setName(String name);

  public boolean isFixed();
  public void setFixed(boolean fixed);

  public double getX();
  public double getY();
  public void setX(double x);
  public void setY(double y);
}
```

The GraphModel provides access to the nodes and edges. We can count the number of elements and add an entry or get an entry, based on its index, in each respective list. While it's possible to traverse a

Listing 1 DefaultGraphModel Class The DefaultGraphModel class is fairly simple. It uses two ArrayList objects for the nodes and edges, respectively.

```
import java.util.*;

public class DefaultGraphModel implements GraphModel
{
  protected ArrayList nodes = new ArrayList();
  protected ArrayList edges = new ArrayList();

  public int getNodeCount()
  {
    return nodes.size();
  }

  public GraphNode getNode(int index)
  {
    return (GraphNode)nodes.get(index);
  }

  public void addNode(GraphNode node)
  {
    nodes.add(node);
  }

  public int getEdgeCount()
  {
    return edges.size();
  }

  public GraphEdge getEdge(int index)
  {
    return (GraphEdge)edges.get(index);
  }

  public void addEdge(GraphEdge edge)
  {
    edges.add(edge);
  }
}
```

graph from any node directly by forcing nodes to be part of a model like this one, it's much easier to manage drawing and selection operations than it would be if graph traversal was always required.

```
public interface GraphModel
{
 public int getNodeCount();
 public GraphNode getNode(int index);
 public void addNode(GraphNode node);

 public int getEdgeCount();
 public GraphEdge getEdge(int index);
 public void addEdge(GraphEdge edge);
}
```

With these interfaces in hand, we can implement the default classes. Since this project has close to 20 classes, we'll only show some of the default implementations. Both the GraphEdge and the GraphNode implementations are trivial. The constructors allow you to set each of the values on creation and the accessors let you set and get the values as we've already defined. Since that's all there is to it, we won't list those classes here in print, though you can get all the classes online at www.java-pro.com.

Listing 1 shows the DefaultGraphModel class, which is relatively uncomplicated. We use two ArrayList objects for the nodes and edges, respectively. The two methods that retrieve the node or edge counts simply use the List interface `size()` method. We map directly on to the List `add()` and `get()` methods for the rest of the interface. In Java 1.1 we might use a Vector to accomplish the same thing, but the Java 1.2 Collections API provides faster implementations because they are not synchronized by default. ArrayList serves exactly the same purpose as a Vector class, but operates much more quickly.

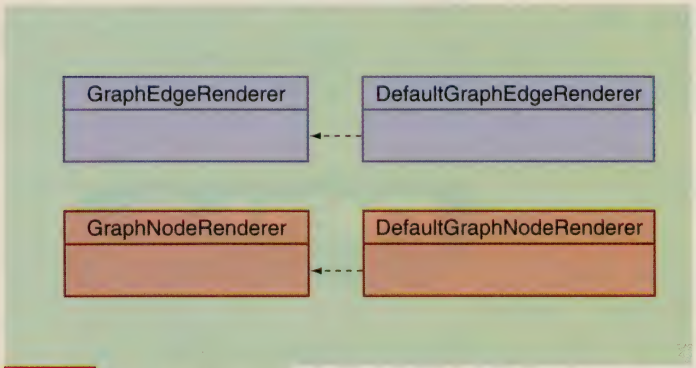

Figure 2 Renderer Classes The two renderer interfaces in our JGraph design are responsible for drawing nodes and edges. Two default renderers are also included in the design.

Flexible Rendering

As we did with our model, we want to maximize flexibility in the user interface. To do this, we'll define two renderer interfaces responsible for drawing nodes and edges (see Figure 2). Nodes are drawn locally wherever the model dictates the location should be. Edges have to be handled differently using the graph's whole coordinate system to draw properly between nodes. In other words, we can draw nodes by rendering a JComponent at the current node position, but to draw edges between nodes, we need to have a JComponent that covers the whole drawing area.

ArrayList serves exactly the same purpose as a Vector class but operates much more quickly

As always, I'll provide default renderers, so you shouldn't have to implement anything special. Should you want to customize the `JGraph` display, however, the design supports it and puts the power in your hands. Let's take a look at the interfaces.

The `GraphNodeRenderer` interface declares a single method called `getGraphNodeRendererComponent()`, which returns a JComponent reference. We could have allowed heavyweight AWT Components to be returned—most of the Swing interfaces do—but this is not very useful in a lightweight component. While it might make some sense for the node renderer, it quickly becomes obvious that heavyweight components make poor edge renderers since they cover the entire space and obliterate the rest of the display by virtue of their background fill.

```
public interface GraphNodeRenderer
{
 public JComponent
   getGraphNodeRendererComponent(
   JGraph graph, GraphNode node,
```

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Listing 2 DefaultGraphNodeRenderer This listing defines a red color for fixed nodes and a yellowish-orange color for all other nodes. It also defines a normal and focus border.

```
import java.awt.*;
import javax.swing.*;
import javax.swing.border.*;

public class DefaultGraphNodeRenderer extends JLabel
  implements GraphNodeRenderer
{
  protected final Color fixedColor =
    Color.red;
  protected final Color nodeColor =
    new Color(250, 220, 100);
  protected final Border normalBorder =
    new EtchedBorder(EtchedBorder.RAISED);
  protected final Border focusBorder =
    new LineBorder(Color.blue, 2);

  public DefaultGraphNodeRenderer()
  {
    setBorder(normalBorder);
    setOpaque(true);
  }

  public JComponent getGraphNodeRendererComponent(
    JGraph graph, GraphNode node, boolean hasFocus)
  {
    setText(node.getName());
    setBackground(node.isFixed() ? fixedColor : nodeColor);
    setBorder(hasFocus ? focusBorder : normalBorder);
    return this;
  }
}
```

Listing 3 DefaultGraphEdgeRenderer In this listing, we set up a few colors for convenience. We also use a couple of instance variables to hold a reference to the edge being drawn and a flag that determines whether stress values should be shown.

```
import java.awt.*;
import javax.swing.*;
import javax.swing.border.*;

public class DefaultGraphEdgeRenderer extends JPanel
  implements GraphEdgeRenderer
{
  protected final Color textColor = Color.darkGray;
  protected final Color normalColor = Color.black;
  protected final Color stressColor = Color.red;

  protected GraphEdge edge;
  protected boolean showStress;

  public JComponent getGraphEdgeRendererComponent(
    JGraph graph, GraphEdge edge, boolean showStress)
  {
    this.edge = edge;
    this.showStress = showStress;
    return this;
  }

  public void paintComponent(Graphics g)
  {
    int x1 = (int)edge.getFrom().getX();
    int y1 = (int)edge.getFrom().getY();
    int x2 = (int)edge.getTo().getX();
    int y2 = (int)edge.getTo().getY();
    int len = (int)Math.abs(Math.sqrt(
      (x1 - x2) * (x1 - x2) + (y1 - y2) * (y1 - y2)) -
      edge.getWeight());
    g.setColor((len < 10) ? normalColor : stressColor);
    g.drawLine(x1, y1, x2, y2);
    if (showStress)
    {
      g.setColor(textColor);
      g.drawString(String.valueOf(len),
        x1 + (x2 - x1) / 2, y1 + (y2 - y1) / 2);
    }
  }
}
```

```
  boolean hasFocus);
}
```

The `getGraphNodeRendererComponent()` method is the only method we need. It expects a reference to the `JGraph` component, a reference to the current node to be painted, and a boolean flag that tells us whether the node currently has the focus.

The `GraphEdgeRenderer` interface handles drawing edges. It declares a method called `getGraphEdgeRendererComponent()` that returns a JComponent object. If you implement your own renderer, make sure the component is not opaque or you'll end up with a single edge in the display area. The arguments include a reference to the `JGraph` component, the edge being rendered, and a flag indicating whether the stress value should be displayed.

```
public interface GraphEdgeRenderer
{
 public JComponent
  getGraphEdgeRendererComponent(
  JGraph graph, GraphEdge edge,
  boolean showStress);
}
```

Now that we've defined the interfaces, let's implement the default renderers.

Listing 2 shows the `DefaultGraphNodeRenderer`. We define a couple of colors, one for fixed nodes and a normal color for all other nodes. We also define a normal and focus border. The normal border is just a raised EtchedBorder and the focus border uses a flat two-pixel blue border. The constructor sets the normal border and also makes sure the node is opaque so that the background is always properly drawn.

The `getGraphNodeRendererComponent()` method does the real work. We're subclassing a JLabel component, so we first set the node's name as the text value. We also set the background, based on whether the node is fixed or not, and the border, based on whether we have the focus or not.

Listing 3 shows the `DefaultGraphEdgeRenderer`. We set up a few colors for convenience. These define the text color used to display the stress value (based on the edge's weight value), and a normal and stress color for the edge line. We'll show the edge in red if it's under greater stress and in black if it's in the normal state. We use a couple of instance variables to hold a reference to the edge being drawn and a flag that determines whether stress values should be shown. This is information we receive through the `getGraphEdgeRendererComponent()` method that we want available when we paint the component.

The `paintComponent()` method does most of the work. We first get *x* and *y* position information from the two nodes at each end of the edge using the GraphEdge interface `getFrom()` and `getTo()`

methods. We then perform a Pythagorean calculation to get the physical length of the line and subtract the weight we assigned for the edge. From this, we can determine if we're under stress and decide which color to use. Then we just draw the line. Optionally, we draw the text that represents the calculated stress value if the showStress flag is set.

JGraph Automation

If you've tried running the graph example that comes with the JDK, you may have seen self-adjusting nodes that settle into a usable configuration through convergence. To make it possible to add this kind of intelligence to our `JGraph` component, we'll define one last interface called GraphAdjuster and provide several implementations that do interesting things, including emulating the same behavior that the JDK example demonstrates. Our solution allows plug-and-play functionality through these interfaces, so these various behaviors are intended to demonstrate how useful this approach can be.

To draw edges between nodes, we need to have a JComponent that covers the whole drawing area

```
public interface GraphAdjuster
{
  public void adjust();
}
```

We'll implement four instances of this class, as shown in Figure 3. Two of them will scramble and shake the nodes on demand. We'll name these `ScrambleAdjuster` and `ShakeAdjuster`, respectively. Another adjuster, `RandomAdjuster`, periodically moves a single node at random and runs as a separate thread. Since we may want to use background threads like this fairly often, I've created an `AutomaticAdjuster` utility class you can use with any GraphAdjuster implementation. Its purpose is to call the adjust method at a predetermined interval you specify. You can see what that looks like in Listing 4.

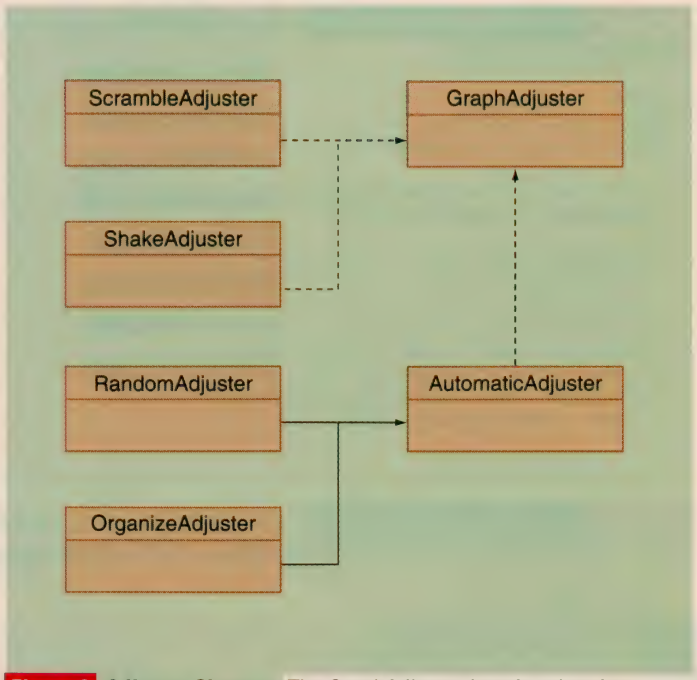

Figure 3 Adjuster Classes The GraphAdjuster interface has four implementations that instigate interesting behaviors: ScrambleAdjuster, ShakeAdjuster, RandomAdjuster, and OrganizeAdjuster.

The most complicated GraphAdjuster implementation is `OrganizeAdjuster`, which implements the behavior from the JDK example running as a background thread. `OrganizeAdjuster` requires a specialized GraphNode object called OrganizeGraphNode, which extends DefaultGraphNode because it needs access to velocity information for each node. Although I could have made this part of the interface definition for GraphNode, it didn't make sense to add a set of attributes with such a specific purpose to the interface. So if you want to use `OrganizeAdjuster`, the nodes have to be of this type or nothing useful will happen.

Listing 4 AutomaticAdjuster Class The AutomaticAdjuster utility class can be used with any GraphAdjuster implementation. It calls the adjust() method at a predetermined interval.

```
public class AutomaticAdjuster extends Thread
{
  protected boolean stop = false;
  protected GraphAdjuster adjuster;
  protected int interval;

  public AutomaticAdjuster(GraphAdjuster adjuster)
  {
    this(adjuster, 100);
  }

  public AutomaticAdjuster(
    GraphAdjuster adjuster, int interval)
  {
    this.adjuster = adjuster;
    this.interval = interval;
    start();
  }

  public void run()
  {
    while (!stop)
    {
      adjuster.adjust();
      try
      {
        Thread.sleep(interval);
      }
      catch (InterruptedException e)
      {
        break;
      }
    }
  }

  public void quit()
  {
    stop = true;
  }
}
```

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Listing 5 Make Mine Scrambled The ScrambleAdjuster class stores a reference to the JGraph object, which we use in the adjust() method to get the size of the drawing area. From that, we randomly reposition each node in the model and call the repaint() method to refresh the view.

```
import java.awt.*;

public class ScrambleAdjuster implements GraphAdjuster
{
  protected JGraph graph;

  public ScrambleAdjuster(JGraph graph)
  {
    this.graph = graph;
  }

  public void adjust()
  {
    Dimension area = graph.getSize();
    GraphModel model = graph.getModel();
    for (int i = 0; i < model.getNodeCount(); i++)
    {
      GraphNode node = model.getNode(i);
      node.setX(10 + (area.width - 20) * Math.random());
      node.setY(10 + (area.height - 20) * Math.random());
    }
    graph.repaint();
  }
}
```

Listing 6 JGraph In the JGraph implementation, we set up a CellRendererPane to use in our drawing. We also set up our default node and edge renderers and the default graph model.

```
import java.util.*;
import java.awt.*;
import java.awt.event.*;
import javax.swing.*;

public class JGraph extends JPanel
  implements MouseListener, MouseMotionListener,
    KeyListener, FocusListener
{
  protected CellRendererPane rendererPane =
    new CellRendererPane();
  protected GraphNodeRenderer nodeRenderer =
    new DefaultGraphNodeRenderer();
  protected GraphEdgeRenderer edgeRenderer =
    new DefaultGraphEdgeRenderer();
  protected GraphModel model =
    new DefaultGraphModel();

  protected boolean showStress;
  protected GraphNode selection;
  protected boolean selectionFixed;
  protected int focusIndex = 0;

  public JGraph()
  {
    addKeyListener(this);
    addFocusListener(this);
    addMouseListener(this);
  }

  public GraphModel getModel()
  {
    return model;
  }

  public void setModel(GraphModel model)
  {
    this.model = model;
  }

  public void paintNode(
    Graphics g, GraphNode node, boolean hasFocus)
  {
    Component component =
      nodeRenderer.getGraphNodeRendererComponent(
      this, node, hasFocus);
    Dimension size = component.getPreferredSize();
    rendererPane.paintComponent(g, component, this,
      (int)node.getX() - (size.width / 2),
      (int)node.getY() - (size.height / 2),
      size.width, size.height);
  }

  public void paintEdge(Graphics g, GraphEdge edge)
  {
    Component component =
      edgeRenderer.getGraphEdgeRendererComponent(
      this, edge, showStress);
    Dimension size = getSize();
    rendererPane.paintComponent(g, component, this,
      0, 0, size.width, size.height);
  }

  public void paintComponent(Graphics g)
  {
    Dimension size = getSize();
    g.setColor(getBackground());
    g.fillRect(0, 0, size.width, size.height);
    for (int i = 0; i < model.getEdgeCount(); i++)
    {
      paintEdge(g, model.getEdge(i));
    }
    for (int i = 0; i < model.getNodeCount(); i++)
    {
      paintNode(g, model.getNode(i),
        hasFocus() && i == focusIndex);
    }
  }

  private double distance(Point point, GraphNode node)
  {
    double x = point.getX() - node.getX();
    double y = point.getY() - node.getY();
    return Math.sqrt(x * x + y * y);
  }

  public boolean isFocusTraversable()
  {
    return true;
  }

  public void focusLost(FocusEvent event)
  {
    repaint();
  }

  public void focusGained(FocusEvent event)
  {
    repaint();
  }

  public void keyTyped(KeyEvent event) {}
  public void keyReleased(KeyEvent event) {}
  public void keyPressed(KeyEvent event)
  {
    int code = event.getKeyCode();
    if (code == KeyEvent.VK_UP ||
      code == KeyEvent.VK_LEFT)
    {
      focusIndex++;
      int max = model.getNodeCount() - 1;
      if (focusIndex > max) focusIndex = 0;
      repaint();
```

Continued on page 54.

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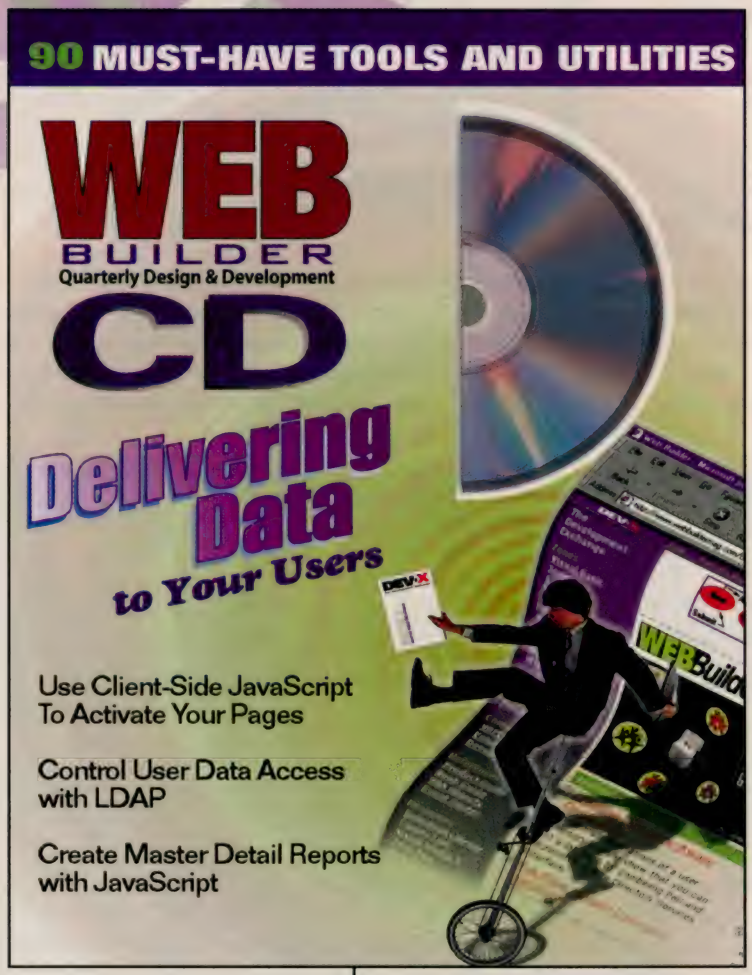

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The GraphAdjuster classes can be simple or complicated. Listing 5 shows `ScrambleAdjuster`. The constructor stores a reference to the `JGraph` object, which we use in the `adjust()` method to get the size of the drawing area. From that, we randomly reposition each node in the model and call the `repaint()` method to refresh the view. `ShakeAdjuster` does virtually the same thing, but rather than randomly repositioning the nodes anywhere in the drawing area, the nodes are randomly moved a smaller random distance from their current position.

There isn't enough room to drill down into the `OrganizeAdjuster`, so I'll just mention a few things for clarity. The algorithm comes from the Graph example that ships with the JDK. The implementation discussed in this article, however, is much cleaner than what you'll see in the JDK example, and intentionally uncoupled from the drawing code. As you can see from our design, this makes it possible to process the nodes without any negative impact on the overall design. I couldn't resist exploring the JDK example because, for me, the whole graph came to life when this behavior was attached to it.

Pulling it All Together

Let's briefly touch on the user interface requirements and then put all this together in the `JGraph` class. Useful components typically provide mouse and keyboard control. In our case, we want to be able to handle focus events and node selection, as well as the fixed state of the node. When a node is considered "fixed" we can avoid moving it, depending on the type of adjuster we're using. We have to be able to toggle that state, so we'll use the space bar on a selected node or a right click of the mouse to do this.

To move between node selections, we use the arrow keys to cycle through the nodes in the model. At times this might seem awkward because we won't move in the direction we chose. This is the only way to ensure we can cycle through each node without overcomplicating our problem. We can select nodes with appropriate mouse clicks to make it easier, but it's important we also implement useful keyboard navigation.

Listing 6 shows the `JGraph` implementation. We set up a CellRendererPane to use in our drawing. This is a Swing class that makes it possible to handle renderers more effectively. We also set up our default node and edge renderers and the default graph model. A few other instance variables keep track of whether we'll show the stress values, keep a reference to the currently selected node, store a flag indicating whether the current node is fixed, and keep an index into the node list that we can increment and decrement when we move between nodes.

The implementation discussed in this article is much cleaner than what you'll see in the JDK example

The `JGraph` component implements the focus, mouse, and keyboard listener interfaces, so we register these in the constructor.

TechTIP

Aligned Columns in java.awt.List

You can use or extend java.awt.List to create a simple multicolumn list. In order to do so, you need to use a fixed character width font set like Courier.

Suppose you have a java.awt.List object, called multiList, sitting on your GUI and you want your multiList to have three columns, each 20 characters long.

```
//define some data members
private final static String PAD_CHARACTER = " "; //space
private int[] widths ={20,20,20};
private String[] padStrings = new String[widths.length];
```

Now, create as many padding strings as your columns, each as wide as your widths:

```
for(int i=0; i<widths.length; i++)
{
  //use StringBuffer for efficiency
  StringBuffer sBuff = new StringBuffer();
  for(int j=0; j<widths[i]; j++)
  {
    sBuff.append(PAD_CHARACTER);
  }
  padStrings[i]=sBuff.toString();
}
```

Say you want to insert "999999,""JOHN,""DOE" as a row of data, and you want it to be bold:

```
String[] entries = new String[3];
entries[0] = "JOHN";
entries[1] =  "DOE";
entries[2] = "999 WHICHEVER STREET";
multiList.setFont(new Font("Courier", Font.BOLD, 12));
insertRow(multiList,entries);
```

Let's insert another row of data just for fun:

```
entries[0] = "JANETTE";
entries[1] =  "DOVE";
entries[2] = "999 SAME STREET";
insertRow(multiList,entries);
```

Note that before calling the `insertRow()` method, you should check if the length of your entries corresponds to the width of each column, and if not, take appropriate action.

Voilà, you have your multiList all aligned for three columns. The following is the code for method `insertRow()`:

```
public void insertRow(List aList, String[] rowItems)
{
  StringBuffer sb = new StringBuffer();
  for(int item=0; item<rowItems.length; item++)
  {
  //use StringBuffer for efficiency
  sb.append(rowItems[item]);

sb.append(padStrings[1].substring(0,widths[1]-
rowItems[item].length()));
  }

  aList.addItem(sb.toString());
}
```

—Behrouz Fallah

Continued from page 52.

```
    }
    if (code == KeyEvent.VK_RIGHT ||
      code == KeyEvent.VK_DOWN)
    {
      focusIndex--;
      int max = model.getNodeCount() - 1;
      if (focusIndex < 0) focusIndex = max;
      repaint();
    }
    if (code == KeyEvent.VK_SPACE)
    {
      GraphNode node = model.getNode(focusIndex);
      node.setFixed(!node.isFixed());
      repaint();
    }
  }

  public void mouseClicked(MouseEvent event) {}
  public void mouseEntered(MouseEvent event) {}
  public void mouseExited(MouseEvent event) {}
  public void mouseMoved(MouseEvent event) {}

  public void mousePressed(MouseEvent event)
  {
    requestFocus();
    addMouseMotionListener(this);
    double closest = Double.MAX_VALUE;
    Point point = event.getPoint();
    for (int i = 0; i < model.getNodeCount(); i++)
    {
      GraphNode node = model.getNode(i);
      double dist = distance(point, node);
      if (dist < closest)
      {
        selection = node;
        closest = dist;
        focusIndex = i;
      }
    }
    boolean rightButton =
      SwingUtilities.isRightMouseButton(event);
    if (rightButton) selection.setFixed(
      !selection.isFixed());
    selectionFixed = selection.isFixed();
    selection.setFixed(true);
    selection.setX(point.getX());
    selection.setY(point.getY());
    repaint();
  }

  public void mouseReleased(MouseEvent event)
  {
    removeMouseMotionListener(this);
    selection.setX(event.getPoint().getX());
    selection.setY(event.getPoint().getY());
    selection.setFixed(selectionFixed);
    selection = null;
    repaint();
  }

  public void mouseDragged(MouseEvent event)
  {
    selection.setX(event.getPoint().getX());
    selection.setY(event.getPoint().getY());
    repaint();
  }
}
```


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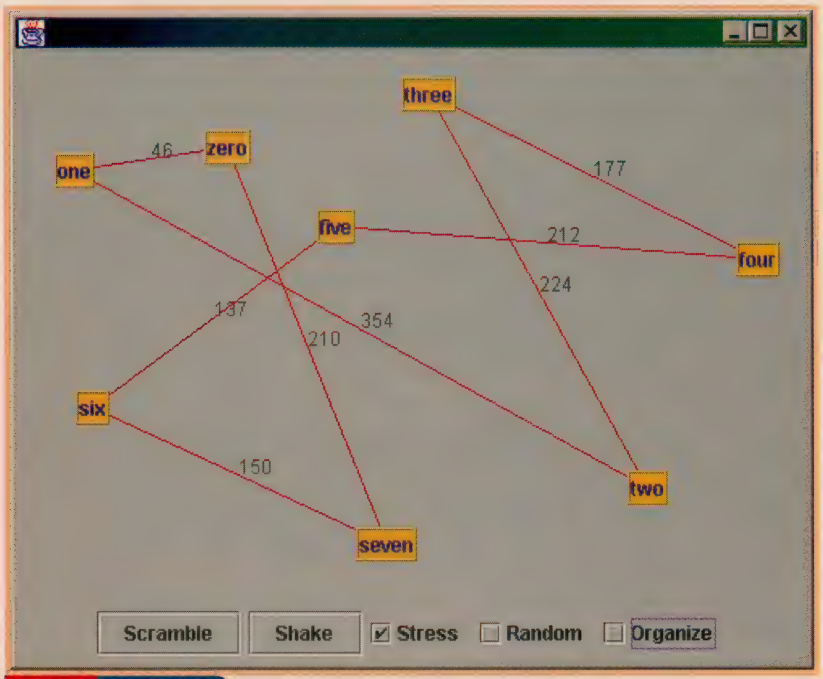

Figure 4 JGraphTest The JGraphTest class shows how the JGraph component behaves.

Much of our code is dedicated to handling these events. The component returns true in the `isFocusTraversable()` method to tell Swing it can manage the focus. The only thing that changes when we get or lose the focus is handled in the `paintComponent()` method, so all the `focusLost()` and `focusGained()` methods need to do is call `repaint()`.

For keyboard events all we need is the `keyPressed()` method to recognize a few keystrokes. We handle DOWN and RIGHT identically, moving to the next node, and UP and LEFT both move to the previous node. All we need to do is increment or decrement the focusIndex value, handling wraparound conditions, and repaint when we're done to refresh the display. If the space key is pressed, we get the current node (based on the focusIndex), toggle its fixed state, then repaint.

The mouse events are only slightly more complicated because we support dragging nodes around. The mouse pressed event requests the focus and adds a mouse motion listener. It then finds the node closest to the mouse position by walking the list of nodes in the model. If the right mouse button was used, we toggle the fixed state for the node. In either case, we store some critical values that will be restored on mouse release and set things up so we can drag the node around before repainting to reflect our changes. The `mouseReleased()` method restores these settings and removes the mouse motion listener before repainting. The `mouseDragged()` method just moves the node to a new position and repaints the display.

Aside from the paint handling, only two methods provide accessors to get and set the model. The `paintComponent()` method does most of the work, with the support of `paintNode()` and `paintEdge()` methods. Each of these calls a renderer with setup information for the node or edge to be painted. It determines what the rendering size is and then uses the CellRendererPane to paint the component. This division of labor makes `paintComponent()` easier to read because it merely draws the background and walks the model list of edges and nodes, delegating the paint operations to the `paintNode()` and `paintEdge()` methods.

You might be wondering about the number of paint events upon which we are relying—that's a reasonable concern. For graphs that have a limited set of nodes, this component will perform well, but performance will degrade as the number of nodes and edges grows. Unfortunately, the kinds of optimizations required to focus on drawing performance are varied and make the code much more difficult to read or explain. And because of limited time, I wasn't able to do much work in this area. I thought the 19 classes in this article were challenging enough to get just right. I hope you'll agree that the open architecture provides plenty of value and I encourage you to consider making drawing optimizations yourself.

If you pull everything down from www.java-pro.com, you'll find a `JGraphTest` class you can run to see how the `JGraph` component behaves. Figure 4 shows `JGraphTest` in action. The Scramble button triggers the `ScrambleAdjuster` and the Shake button triggers the `ShakeAdjuster`. The Stress checkbox determines whether the numerical values on each edge are shown. The Random checkbox determines whether periodic, single-node adjustments are used to help the graph adjustment stay out of local minima conditions (a fancy way of saying it introduces random events to avoid getting stuck). The RandomCheck box starts an `AutomaticAdjuster` with a `RandomAdjuster` and calls the `quit()` method when you toggle it off.

The Organize checkbox determines whether the `OrganizeAdjuster` is active. This works the same way as the `RandomAdjuster`, using the `AutomaticAdjuster` to handle threading. This test configuration will eventually settle into a circle. I toggled off Organize to stop it from moving long enough to get the screen shot, but you can play with this all you like. I think you'll find it interesting.

I hope you derive some enjoyment from this component as well as an appreciation for using interfaces effectively. In this case, we can swap three kinds of modeling elements, two renderers, and any number of behavior adjusters associated with our graph. The modeling allows us to display any suitable data source. The renderers allow us to change the look of each element as needed and the adjusters provide a flexible way of handling directly triggered or automated events that move nodes around in the display. Taken with easily extensible default classes, this component represents a solid foundation to fill your graph display needs. I hope it serves you well. ■

Claude Duguay is the Software Engineering Manager at Atrieva Corp. in Seattle, Washington. He has written for several programming magazines and has been programming for over nearly two decades. Reach him at claude@atrieva.com.

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Let's Waba

For handheld users looking for a Java-based development system, Waba is good to go

BY RICK GREHAN

For those of you who are among the growing number of owners of handheld devices (such as Palm and Windows CE machines) and who would like to take your Java capabilities to new lows—in terms of size, that is—there's Waba.

Waba is a VM and an SDK that uses a subset of Java for small devices. In this day of single-chip, 16-pin microcontrollers, "small" can mean an 8-bit device with 256 bytes of RAM. So, let me put this in context: A Waba runtime environment can execute in as little as 64K. As of this writing, versions of Waba exist for Palm handhelds and for Windows CE systems. New ports of Waba are expected in the future, so you should check for updates at the Wabasoft site, www.wabasoft.com.

Now, a 64K Java runtime environment is obviously missing some pieces of a full Java system. Indeed, Waba is more accurately defined as a proper subset of Java. Considered merely as a language subset, Waba lacks longs and doubles, has no multithreading, and does not support exceptions. Waba dispenses with the standard Java packages and provides its own set of six that comprise Waba's "foundation" classes: lang, sys, fx, ui, io, util. I'll describe these in detail later.

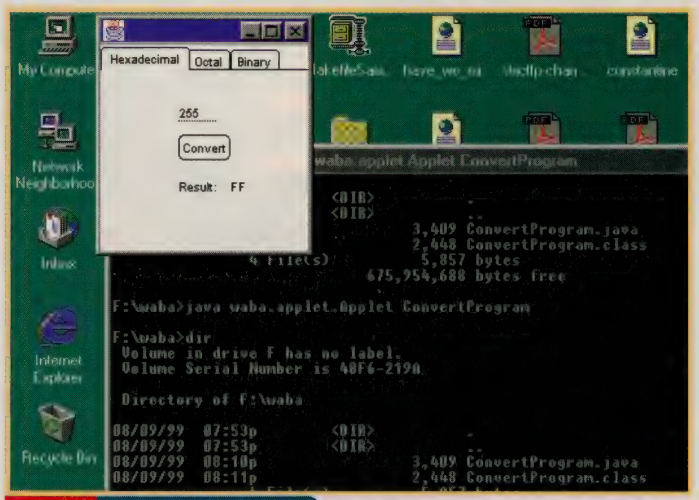


Figure 1 Waba on the Desktop Here, the application shown in Listing 1 runs on a Windows NT desktop. (Waba is also compatible with Windows 95, and a Linux version may be ready by the time you read this.) Though the Waba screen seems Spartan, keep in mind that one of Waba's primary targets are PalmOS systems, which enjoy much less screen real-estate and resolution than a desktop system.

The Waba SDK

The free Waba SDK is self-installing. If you download and run the installation, it creates and populates several subdirectories on your system. (One advantage of Waba's modest size is that it doesn't erupt into megabytes upon megabytes of files, as do other development systems.)

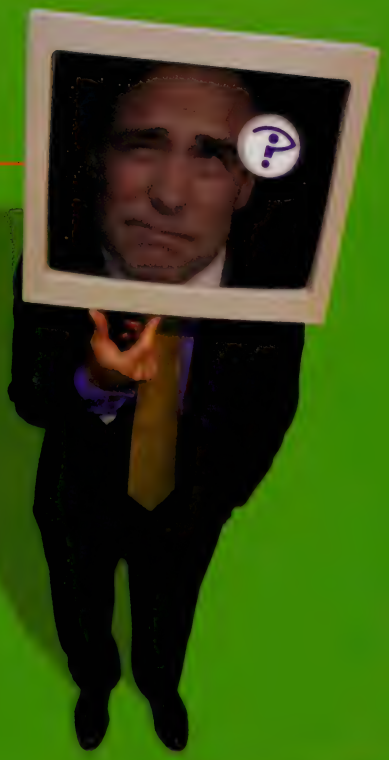
The Waba SDK includes a complete set of linked HTML documents for all the classes and associated methods in the Waba foundation packages. In addition, the SDK comes with all the source code for the foundation classes, allowing you to extend those classes in whatever way you consider appropriate for your application. (To get started programming Waba, Wabasoft's Web site contains several useful tutorial articles.)

Waba arrives with a collection of seven example programs. The simplest is probably the PocketWatch application, which shows off features in the waba.fx package. A look at the source for PocketWatch shows how to load and display bitmap images. It also shows how to create and use a timer object.

One of the more complex applications is Web, which demonstrates how Waba can be used to create a simple HTML parser. If you have a Palm, the AddrScan application is a Waba program that can open and read the Palm's address book database.

Waba Packages

As I mentioned, Waba does not support the standard collection of packages that you'll find in a full-blown Java system. Many of the packages we take for granted simply can't be supported by Waba. For example, given that Waba does not have a double floating-point data type, it can't include a Math package because all of the trigonometric and transcendental functions operate on double values. (Of course, there's nothing stopping anyone from creating a single-precision ver-



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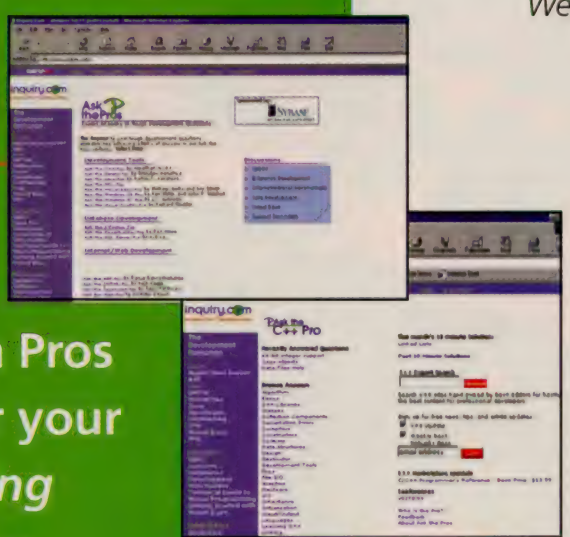

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sion of those functions. But it's unlikely this type of function would be warranted on the kinds of systems Waba targets.)

The Waba SDK contains six packages:

waba.lang This is Waba's base package. It includes three classes: Object, String, and StringBuffer. These classes implement objects that have limited capability as compared to their Java counterparts. For example, the only methods recognized by StringBuffer objects are `append()` and `toString()`. (StringBuffer objects do recognize the overloading of "+" and "+=" operators for concatenation.)

waba.sys This package includes classes that provide system-level methods. For example, you can query the hardware to determine if it supports a color display. This package includes methods for performing high-speed array copies (using native methods), as well as a method to put the VM to sleep for a specified number of milliseconds.

A Waba runtime environment can execute in as little as 64K

waba.fx This is the effects package, and it includes classes for manipulating 2D graphics (drawing lines, rectangles, and so on), images, fonts, and sound.

waba.ui The Waba user interface package is populated with classes that provide a healthy (though not overwhelming) collection of visual widgets. These include button, text entry control (an edit field), radio buttons, tab bar, and checkboxes. Other classes within this package provide Waba's event management system; still others deal with user input devices (such as pens and keyboard entry).

waba.io Waba's I/O package is geared to the sorts of I/O found on handheld systems. The waba.io package includes classes for managing serial I/O (for communication between handheld and host PC) and network I/O (Waba includes TCP/IP socket support). In addition, the `waba.io` package has some specialized file-system support. Specifically, Waba supports a Catalog class. A Catalog object is a collection of records that can be used as a small database. Catalog objects act somewhat like a random file (in that you can arbitrarily set the current record position) with the added capability that records can be added and deleted.

waba.util This final catch-all package is meant to carry general-purpose classes. In the current version of Waba, The waba.util package contains a single class, Vector.

The Main Events

A Waba application is not written with a `main()` method. Rather, the starting method is `MainWindow()`. Actually, there *is* a `main()` method, you just don't see it. Waba's `main()` sets up the Waba environment, then transfers control to `MainWindow()`. So from the application programmer's point of view, `MainWindow()` is `main()`.

Within the `MainWindow()` method is a set of four methods that serve as the explicit event handlers of the Waba runtime. These event-handling methods are called the "on" methods on account of the first two letters of their names:

- `onStart()`: This method is called when a Waba application is first launched. An application can use it, for example, to ascertain specifics of the current hardware platform and adjust parameters accordingly.
- `onExit()`: This method is called just before a method terminates. Programs can use `onExit()` to clean up after themselves

Listing 1 Number Conversion in Waba This is a simple Waba program that shows off some of the user interface controls. The ConvertProgram() constructor merely populates the Waba screen with the controls. All the real work takes place inside onEvent(), which the Waba runtime calls in response to a user event. In this case, the application responds only to PRESSED events—the user pressing one of the tabs or the convert button.

```
// Simple Waba application Conversion to hexadecimal,
// octal, and binary
import waba.ui.*;
import waba.fx.*;

public class ConvertProgram extends MainWindow
{

// Define Tabbar and tabs
TabBar tabbar;
Tab hexTab;   // Hexadecimal
Tab octTab;   // Octal
Tab binTab;   // Binary
// Convert button
Button convButton;
// Edit box
Edit editBox;
// Result Label
Label label;
// Current base.
// 16=hex, 8=oct, 2=bin
int currBase;

// Input and output strings
String inpData;
String outData;

// Graphics object for output
Graphics g;

// Char array for conversion
char cchars[] =
{ '0', '1', '2', '3', '4', '5', '6', '7',
  '8', '9', 'A', 'B', 'C', 'D', 'E', 'F' };

//
// ConvertProgram()
//
public ConvertProgram()
{

// Start in hex
currBase=16;

// Make a graphics object
g = new Graphics(this);

// Create Tab bar. Add new tabs. Then add tabbar
tabbar = new TabBar();
hexTab = new Tab("Hexadecimal");
octTab = new Tab("Octal");
binTab = new Tab("Binary");
tabbar.add(hexTab);
tabbar.add(octTab);
tabbar.add(binTab);
```

Continued on page 62.

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(make sure files are closed, any characters left in a serial port cache are flushed, and so on).

- `onPaint()`: This method is called whenever a control in the application (which could be any graphic object) must be redrawn. The `onPaint()` method receives the graphics object that needs redrawing as an input argument.
- `onEvent()`: This is Waba's workhorse method. Whenever an event from the Waba runtime is dispatched to an executing application, the runtime calls `onEvent()`. The input argument to `onEvent()` is the event object that represents the event that took place. By examining fields within the event object, you can determine what sort of event occurred (such as the user dragged the pen across the screen, a button was pressed, and so on) as well as information about the event location (the pen's coordinates, which button was pressed, and so on).

Working with Waba

Waba is a cross-development system. You use the standard Sun JDK to compile Waba programs. Since Waba uses its own foundation classes, there's little concern about which JDK version. Waba programs can be compiled using JDK 1.0.2 compilers up through JDK 1.2 compilers.

Happily, you don't need a handheld device to execute your Waba program. The Waba SDK comes with a set of bridge classes that interface the Waba foundation classes to the Win32 API. Consequently, you can test your Waba programs on a Windows 95 or NT system—again using Sun's JDK. (This makes for a great development platform. You can work the kinks out of your Waba program before taking it down to your handheld.)

Once you are ready to download your Waba program to your handheld, you have to create an application *launcher*: a program that defines the application's runtime environment (memory allocated to the application, its start-up class) as well as cosmetic details such as the application's icon. You do this with the exegen program (provided with the Waba SDK).

Next, you build a WARP file for the application. WARP stands for Waba Application Resource Package, and is simply a bundle of all the classfiles and other resources that the application needs.

Finally, you need to obtain the appropriate Waba VM for your device. Both Palm and Win CE VMs are available from the Wabasoft Web site. They are *not* part of the Waba SDK—you must download them separately.

Waba Converts

I put together a simple application for Waba, as shown in Listing 1. The application uses several of Waba's controls: a tab bar, edit field,

Continued from page 60.

```
tabbar.setRect(0,0, this.width,20);
 add(tabbar);

// Create and add edit box
editBox = new Edit();
editBox.setRect(60,50,30,10);
add(editBox);

// Create and add conversion button
convButton = new Button("Convert");
convButton.setRect(60,70,40,20);
add(convButton);

// Display result text label
label=new Label("Result:");
label.setRect(60,100,40,20);
add(label);
}

//
// onEvent()
//
// This method is called each time a user event occurs.
// Could be one of the tabs pressed, or the convert
// button pressed.
public void onEvent(Event event)
{

if (event.type==ControlEvent.PRESSED)
{
  // If a tab button is pressed, set the current base
  // accordingly
  if(event.target == hexTab)
    currBase=16;
  if(event.target == octTab)
    currBase=8;
  if(event.target == binTab)
    currBase=2;

  // If the convert button is pressed, do a conversion
  // and display the resulting value.
  if(event.target == convButton)
  {  doConvert();
    // Clear the result field
    g.setColor(255,255,255);
    g.fillRect(100,104,50,20);
    // Display the result
  g.setColor(0,0,0);
    g.drawText(outData,100,104);
    }
}

}

//
// doConvert()
//
// Convert data in edit text box. Result is returned
// in outData string.
public void doConvert()
{
int inpDataInt;
String digitString;
int digit;

  // Get the input string and convert to an int
  inpData=editBox.getText();
  inpDataInt=waba.sys.Convert.toInt(inpData);

  // Initialize output string
  outData="";

  // Loop until input data value exhausted
  while(inpDataInt != 0)
  {
    // Get a digit
    digit=inpDataInt % currBase;

    // Make it a string in the proper number base. (This
    // String() constructor takes as an input a char
    // array. The 2nd argument is the offset, the third
    //is the length.)
    digitString=new String(cchars,digit,1);

    // Attach what we have so far in the output string to
    // this digit. (We get least sig. digits first.)
    outData=digitString.concat(outData);

    // Reduce input data (slice off the digit we just
    // converted).
    inpDataInt=inpDataInt/currBase;
  }

}
}
```

button, and label. I ran the application on my Windows NT system, and Figure 1 shows the result. (I've purposefully shown part of the screen so you'll believe that it's running on a Windows machine).

The application is straightforward. `ConvertProgram()`, the Waba application's equivalent of `main()`, simply creates and displays all the on-screen objects. The real work takes place in the `onEvent()` method (which probably looks a lot like the old event-handling loops in JDK 1.0.2). The only kind of events type that the application responds to is a PRESSED event. A series of `if()` statements filter first for each of the tabs on the tab bar, setting the current conversion base appropriately. If the user presses the "convert" button, the `doConvert()` method is called. It reads the contents of the edit field and performs the base conversion. Then the result is displayed.

Waba uses its own foundation classes so you don't need to worry about which JDK version you use

Compiling the Waba application is straightforward. First, you need to point your CLASSPATH system variable to the classes subdirectory in the Waba SDK's directory path. Then, you run the application with java waba.applet.Applet ConvertProgram. Notice that you don't run your Waba application directly. Instead, you run the Waba runtime, which loads and executes the application just as the VM would on the handheld.

Let's Get Small

Whether Java catches on as a development language for handheld systems remains to be seen. It's at least interesting that both Oracle and Sybase have launched mobile initiatives for placing "lite" versions of their databases on handhelds, and in both cases the development language of choice appears to be Java. In the meantime, if you want to explore Java in tight spaces, try Waba. ■

Rick Grehan is a technical writer for NuMega Technologies. Rick was a Senior Editor at *BYTE* magazine (where he wrote the JavaTalk column) and at *Computer Design* magazine. He can be reached at rgrehan@top.monad.net.

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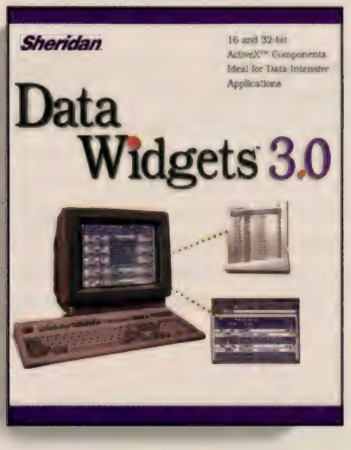

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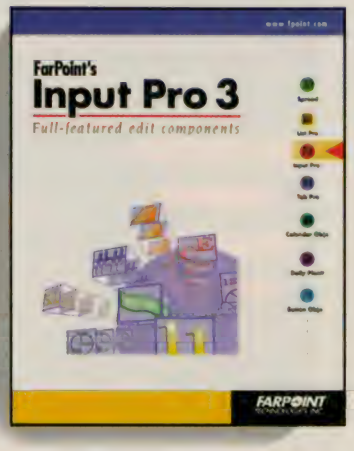

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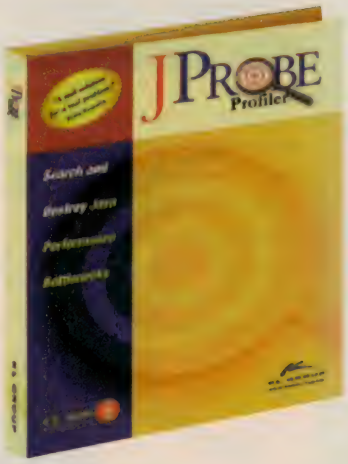

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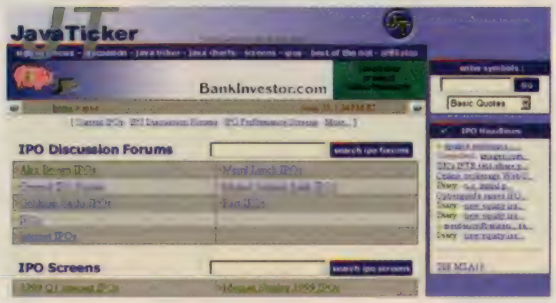

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Continued from page 72.

the constraints for garbage collecting an object and also a way to detect when an object becomes unreachable and eligible for reclamation. An object is reachable when you can trace a series of references to it from a root reference. A root reference is an object referenced on the thread stack or by static class members. You can think of root references as directly accessible objects. Objects reachable through a chain of references originating from a root reference are termed strongly reachable. Strongly reachable objects cannot be garbage collected. The java.lang.ref package provides a way to weaken the reference chain by introducing the concept of a weak reference.

Objects that are weakly referenced can be garbage collected even when they are still usable by a program, so long as they are not strongly reachable. An object is weakly reachable if it is not strongly reachable and the only reference chains that can be traced to it pass through a weak reference. It can be hard to grasp weak references because their definition is kind of circular. Describing how the reference classes work can make it easier to understand.

The reference classes consist of a non-instantiable Reference base class and three subclasses that define different types of weak references: SoftReference, WeakReference, and PhantomReference. A Reference is a wrapper around a Java object, but with black magic inside. You normally think of a wrapper class as containing a reference variable that points to the wrapped object. This can maintain a strongly reachable relationship. A Reference object maintains a weakly reachable relationship with its wrapped object, which is called a referent. In other words, a Reference object's link to its referent will not keep the referent from being garbage collected.

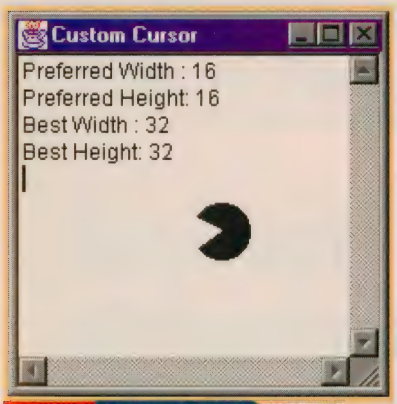

Figure 1 Custom Cursor JDK 1.2 allows you to use an arbitrary image to create a cursor. The cursor dimensions are also displayed.

Why are there three types of weak references? The SoftReference and WeakReference classes are very similar to each other. The only difference is that the garbage collector uses an implementation-dependent algorithm to decide whether or not to reclaim a soft reference whereas a weak reference is always reclaimed. You use a SoftReference when you'd like to give an object a chance to stay alive longer than if it were a weak reference. A PhantomReference represents phantomly reachable objects, which are objects that have been finalized by the garbage collector, but not yet reclaimed. Phantom references must be associated with a ReferenceQueue. This is enforced by the PhantomReference constructor. The garbage collector will place a PhantomReference on a ReferenceQueue sometime after it is finalized. You can poll the ReferenceQueue for the appearance of a PhantomReference in order to perform post-finalization operations, which might normally be handled in a destructor in C++. SoftReference and WeakReference instances may optionally be associated with a ReferenceQueue. SoftReference and WeakReference objects have their reference field set to null by calling the `clear()` method before they are put on the ReferenceQueue. PhantomReferences are placed on the ReferenceQueue without having their referent cleared and it is up to the programmer to call `clear()` as part of the final cleanup. However, the referent of a PhantomReference is always made to be inaccessible, so the `get()` method always returns null.

Strongly reachable objects cannot be garbage collected

I can't cover all the issues and subtleties about references in this column, but I wanted to at least introduce the subject. Listing 1 shows how a WeakReference and PhantomReference should be treated by the garbage collector. It creates a weak reference and a phantom reference, forcing garbage collection after they are no longer strongly reachable. If you try running this test program and it blocks at the queue removal, it may point to a bug in the JVM. I have discovered that at least the Linux 1.2 JDK enters some kind of internal deadlock, perhaps a thread priority inversion, when using native threads and the example has to be run using Green threads.

Q I can set the cursor to a variety of stock cursors (HAND_CURSOR, for example) but would like to use my own images to extend the available cursors. Is this possible?

A JDK 1.0.2 allowed you to change the cursor of a Frame to one of a set of predefined cursors. JDK 1.1 added the ability to set the cursor for any component with the `setCursor(Cursor)` method in java.awt.Component. But you could still only choose from a predefined set of cursors. JDK 1.2 finally added the ability to create your own custom cursors from arbitrary images.

The Toolkit class contains a method with the signature `createCustomCursor(Image cursor, Point hotspot, String name)`. The first argument is the custom cursor image, the second

Continued from page 72.

```
    // Invoke garbage collector in hopes that references
    // will be queued
    System.gc();

    // See if the garbage collector has queued the
    // references
    System.out.println(
      "Weak Queued: " + weakRef.isEnqueued());
    // Try to finalize the phantom references if not already
    if(!phantomRef.isEnqueued()) {
      System.out.println("Requestion finalization.");
      System.runFinalization();
    }
    System.out.println(
      "Phantom Queued: " + phantomRef.isEnqueued());

    // Wait until the weak reference is on the queue
    // and remove it
    try {
      ref = weakQueue.remove();
      // The referent should be null
      System.out.println("Weak Reference: " + ref.get());
      // Wait until the phantom reference is on the queue
      // and remove it
      ref = phantomQueue.remove();
      System.out.println("Phantom Reference: " + ref.get());
      // We have to clear the phantom referent even though
      // get() returns null
      ref.clear();
    } catch(InterruptedException e) {
      e.printStackTrace();
      return;
    }
  }
}
```

Listing 2 Changing Your Cursor JDK 1.2 allows you to create your own custom cursors from arbitrary images. This code creates a cursor that looks like Pac Man.

```
import java.awt.*;
import java.awt.event.*;
import java.awt.image.*;

public class CustomCursor {
  public static final int PREFERRED_CURSOR_WIDTH  = 16;
  public static final int PREFERRED_CURSOR_HEIGHT = 16;

  public static void main(String[] args) {
    Frame frame = new Frame("Custom Cursor");
    TextArea textArea;
    WindowListener exitListener;
    Dimension cursorSize;
    Toolkit toolkit;
    BufferedImage cursorImage;
    Graphics2D graphics;
    Cursor cursor;

    exitListener = new WindowAdapter() {
      public void windowClosing(WindowEvent e) {
        Window window = e.getWindow();
        window.setVisible(false);
        window.dispose();
        System.exit(0);
      }
    };

    frame.addWindowListener(exitListener);

    textArea = new TextArea(40, 10);
    textArea.setEditable(false);
    frame.add(textArea, BorderLayout.CENTER);
    frame.setSize(400, 400);
    frame.setVisible(true);

    textArea.append("Preferred Width : " +
      PREFERRED_CURSOR_WIDTH + "\n");
    textArea.append("Preferred Height: " +
      PREFERRED_CURSOR_HEIGHT + "\n");

    toolkit = Toolkit.getDefaultToolkit();
    cursorSize = toolkit.getBestCursorSize(
      PREFERRED_CURSOR_WIDTH, PREFERRED_CURSOR_HEIGHT);

    textArea.append("Best Width : " +
      cursorSize.width + "\n");
    textArea.append("Best Height: " +
      cursorSize.height + "\n");

    if(cursorSize.width == 0 || cursorSize.height == 0) {
      textArea.append("Custom Cursor not supported.\n");
      return;
    }

    cursorImage = new BufferedImage(
      cursorSize.width, cursorSize.height,
      BufferedImage.TYPE_INT_ARGB);
    graphics = cursorImage.createGraphics();
    // Draw a rectangle of transparent pixels
    graphics.setPaint(new Color(0, 0, 0, 0));
    graphics.fillRect(
      0, 0, cursorSize.width, cursorSize.height);
    // Make a Pacman-shaped cursor
    graphics.setPaint(Color.black);
    graphics.fillArc(
      0, 0, cursorSize.width, cursorSize.height,
      150, -300);

    cursor = toolkit.createCustomCursor(
      cursorImage, new Point(cursorSize.width/2,
      cursorSize.height/2), "Demo Cursor");
    textArea.setCursor(cursor);
  }
}
```

Listing 3 Making Progress The ProgressMonitor class pops up a dialog containing a JProgressBar that displays the progress of an operation.

```
import java.awt.*;
import java.awt.event.*;
import javax.swing.*;

public class Progress {
  public static final int LOOP_MAX = 15000;
  public static void main(String[] args) {
    JFrame frame = new JFrame("Progress Demo");
    ProgressMonitor progress;
    WindowListener exitListener;

    exitListener = new WindowAdapter() {
      public void windowClosing(WindowEvent e) {
        Window window = e.getWindow();
        window.setVisible(false);
        window.dispose();
        System.exit(0);
      }
    };

    frame.addWindowListener(exitListener);
    frame.setSize(400, 400);
    frame.setVisible(true);

    progress = new ProgressMonitor(frame,
      "Executing dummy loop.", "Iterating.", 0, LOOP_MAX);

    for(int i = 0; i <= LOOP_MAX; ++i) {
      // Simulate some work
      for(int j = 0; j <= LOOP_MAX; ++j);
      if(progress.isCanceled())
        break;
      progress.setProgress(i);
    }
  }
}
```

argument is a point indicating which part of the image is the cursor hotspot, and the third is a textual description of the cursor intended for use by the Java Accessibility API. Before you create an Image for your custom cursor, you need to determine a supported size. `Toolkit.getBestCursorSize(int, int)` will return the supported dimension closest to your preferred size. If the implementation does not support custom cursors, a dimension of 0 width and height will be returned.

Listing 2 uses the new cursor customization methods to create a cursor that looks like Pac Man and displays the cursor dimensions, as shown in Figure 1.

Q Is it necessary to check the return value after a "new" statement? Does it return null when it cannot allocate any more memory?

A You do not have to check the return value of the new operator. Unlike C, where `malloc()` will return NULL if it fails, the Java new operator will throw an OutOfMemoryError. OutOfMemoryError is a RuntimeException, so you are not forced to catch it. However, if your program needs to be able to recover from running out of memory, you should place a try block at a strategic point where recovery can be performed.

Q How do I use the ProgressMonitor class?

A The ProgressMonitor class is a convenience class that saves you from the hassle of creating your own dialog with a JProgressBar. It will pop up a dialog containing a JProgressBar that displays the progress of an operation. ProgressMonitor will only pop up the

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monitor after a minimum amount of time has passed. The default value is 500 milliseconds and can be set with `setMillisToDecideToPopup(int)`. Based on the progress of the operation up to this point, ProgressMonitor will decide how much longer it will take for the operation to complete. Only if this time is greater than a given threshold will the dialog be displayed. The default threshold is 2 seconds and can be set with `setMillisToPopup()`.

The progress of an operation is conveyed to the ProgressMonitor by calling `setProgress(int)` with an integer argument representing the progress. The ProgressMonitor constructor accepts a minimum value and a maximum value for the progress indicator in order to determine when and how to update the progress bar. Only calls to `setProgress()` that would result in a visible change in the progress bar cause an update of the JProgressBar.

If you are not careful, you can use ProgressMonitor to no effect. The most common cause is when your operation completes too quickly. You can get around this by reducing the pop-up threshold values to zero. Another situation that can occur is that the progress dialog will appear, but no updates will occur. You can prevent this by limiting your calls to `setProgress()` so that the AWT thread has a chance to update the progress bar. In the end, I am not too keen on the ProgressMonitor class. The dialog it creates has both an OK and a Cancel button. The Cancel button makes sense and is intended to terminate the operation. Before calling `setProgress()`, you should test if the operation has been canceled with Boolean `isCanceled()`, which will return true if the cancel button has been pressed. The OK button doesn't make much sense to me and will make the dialog disappear even before the operation has completed. Right now I consider this a bug and don't recommend using ProgressMonitor because the OK button can confuse users.

Listing 3 shows how you might use the ProgressMonitor class. I use a dummy loop to simulate work, but you could imagine that bytes were being read from a socket during a file download.

Q I'd like to incorporate an inactivity timeout for an application. When there is no mouse or keyboard activity in the application for a certain period of time, I want to close all the windows and dialogs of the application. How can I do this?

A The easiest way to implement an inactivity timeout is to keep track of the last time a MouseEvent or KeyEvent was sent to an application. In a separate thread, set a timer that checks periodi-

Listing 4 Taking a Timeout The easiest way to implement an inactivity timeout is to keep track of the last time a MouseEvent or KeyEvent was sent to an application.

```
import java.awt.*;
import java.awt.event.*;
import javax.swing.*;

class TimeoutListener implements MouseListener,
  MouseMotionListener, KeyListener, ActionListener
{
  Object _lock;
  long _timeout, _lastTime;

  public TimeoutListener(long timeout) {
    _lock    = new int[1];
    _timeout= timeout;
    _lastTime = System.currentTimeMillis();
  }

  private void __recordLastEvent(InputEvent event) {
    synchronized(_lock) {
      _lastTime = System.currentTimeMillis();
      System.out.println(
        "Last Event: " + _lastTime + " " + event);
    }
  }

  public void actionPerformed(ActionEvent e) {
    synchronized(_lock) {
      // We really shouldn't exit, but cleanup
      // gracefully instead
      if(System.currentTimeMillis() - _lastTime >=
        _timeout) {
  System.out.println(
    "Timed out! " + System.currentTimeMillis());
  System.exit(0);
      } else
  System.out.println("Still active.");
    }
  }

  public void mouseDragged(
    MouseEvent e) { __recordLastEvent(e); }
  public void mouseMoved(
    MouseEvent e) { __recordLastEvent(e); }
  public void mouseClicked(
    MouseEvent e) { __recordLastEvent(e); }
  public void mouseEntered(
    MouseEvent e) { __recordLastEvent(e); }
  public void mouseExited(
    MouseEvent e) { __recordLastEvent(e); }
  public void mousePressed(
    MouseEvent e) { __recordLastEvent(e); }
  public void mouseReleased(
    MouseEvent e) { __recordLastEvent(e); }
  public void keyPressed(
    KeyEvent e) { __recordLastEvent(e); }
  public void keyReleased(
    KeyEvent e) { __recordLastEvent(e); }
  public void keyTyped(
    KeyEvent e) { __recordLastEvent(e); }
}

public class Timeout {

  public static final int TIMEOUT = 10000;  // milliseconds
  public static void main(String[] args) {
    Frame frame = new Frame("Progress Demo");
    WindowListener exitListener;
    TimeoutListener timeoutListener;
    Timer timer;

    exitListener = new WindowAdapter() {
      public void windowClosing(WindowEvent e) {
        Window window = e.getWindow();
        window.setVisible(false);
        window.dispose();
        System.exit(0);
      }
    };


    timeoutListener = new TimeoutListener(TIMEOUT);
    frame.addMouseListener(timeoutListener);
    frame.addMouseMotionListener(timeoutListener);
    frame.addKeyListener(timeoutListener);
    frame.addWindowListener(exitListener);
    frame.setSize(400, 400);
    frame.setVisible(true);

    // We poll at half the timeout interval to reduce
    // the fudge factor introduced by events delivered at
    // just under the timeout value.
    timer = new Timer(TIMEOUT / 2, timeoutListener);
    timer.setRepeats(true);
    timer.start();
  }
}
```

cally if the difference between the current time and the timestamp is greater than the timeout interval. Listing 4 demonstrates this technique. TimeoutListener keeps track of the last InputEvent sent to the application by implementing MouseListener, MouseMotionListener, and KeyListener. Each time any one of those interface methods is called, TimeoutListener records the current time. TimeoutListener also implements the ActionListener interface so that it may be used with the Swing Timer class. Every time the Timer expires, it invokes the `actionPerformed()` method in its registered ActionListener. TimeoutListener calculates the difference between the last recorded time and the current time when this happens. If it is greater than the timeout value, it exits. The Timer class may be active in a separate thread, so it is necessary to avoid race conditions by protecting the time recording and testing with a synchronized block.

If you're not careful, you can use ProgressMonitor to no effect

The problem with this approach is that it is slightly inaccurate due to the polling. The actual inactivity timeout will be a value between the specified timeout and the timeout plus the polling period. To obtain a more accurate timeout, you can forego polling, set the Timer delay to the timeout value, and restart the Timer every time an event is delivered. When the timer expires, have its ActionListener exit the application. This approach may have a higher overhead because restarting the Swing Timer involves removing the timer from a queue and adding it again in addition to canceling pending firings. ■

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Ask the Java Pro

Referencing Garbage

Java programs are often easier to write than C or C++ programs because you don't have to worry about memory management. The garbage collector does all the work for you. You don't have to mess with `free()`, `delete`, or destructors. It would even seem that memory leaks are a thing of the past as well. It almost sounds too good to be true. As with most things in Javaland, when you dig beneath the surface, you find additional complexity lurking around. Although you can get away with ignoring the complexity, once you start to build large programs, learning about the stuff under the hood can often improve your application's performance and resource utilization.

All the superficial claims about the simplicity of memory management in Java are generally true. Most of the time you can just let the garbage collector do its thing. However, how and when garbage collection is performed depends on the JVM implementation. That is why even in Java 1.0 you were able to force the garbage collector to run by calling `Runtime.gc()`. Actually, this won't guarantee that garbage collection will occur. It will only hint to the JVM that the application would really like the garbage collector run. The JVM can ignore this or pay attention to it. However, most JVMs appear to run the garbage collector shortly after a call to `Runtime.gc()`.

finalize() is often mistaken for the Java equivalent of a destructor

BY DANIEL F. SAVARESE

Another Java memory management feature is the infamous `finalize()` method. This method is often mistaken for the Java equivalent of a destructor. An object's `finalize()` method is called by the garbage collector at some time before the memory used by the object is reused. No other guarantee is made about exactly when the method will be invoked. The purpose of the method is to allow the freeing of resources not under the garbage collector's control. These resources are usually native data such as file descriptors. So we've just encountered the first spot where Java can leak memory—unfreed native resources. Java also provides `Runtime.runFinalization()` to request that the garbage collector run the finalizers of eligible objects. Again, no guarantee is made that this will happen immediately after the call.

Listing 1 Treated like Garbage This sample code creates a weak reference and a phantom reference, forcing garbage collection after they are no longer strongly reachable. This is how a WeakReference and PhantomReference *should* be treated by the garbage collector.

```
// References.java,v 1.1 1999/09/09 23:48:05

import java.lang.ref.*;

public class References {
  public static void main(String[] args) {
    Object weakObj, phantomObj;
    Reference ref;
    WeakReference weakRef;
    PhantomReference phantomRef;
    ReferenceQueue weakQueue, phantomQueue;

    weakObj    = new String("Weak Reference");
    phantomObj = new String("Phantom Reference");
    weakQueue    = new ReferenceQueue();
    phantomQueue = new ReferenceQueue();
    weakRef    = new WeakReference(weakObj, weakQueue);
    phantomRef = new PhantomReference(
       phantomObj, phantomQueue);

    // Print referents to prove they exist. Phantom referents
    // are inaccessible so we should see a null value.
    System.out.println("Weak Reference: " + weakRef.get());
    System.out.println(
       "Phantom Reference: " + phantomRef.get());

    // Clear all strong references
    weakObj    = null;
    phantomObj = null;
```

Continued on page 67.

If these were the only gotchas to Java memory management, it might be fair to accuse me of exaggerating about the complexity. Of course, there's more. Java programs can often consume excess memory because they maintain references to objects that are no longer needed. That is another way that Java can leak memory. The most common situations where leaks occur are when a program caches data (for example, a Web browser) or uses opaque data structures such as hashtables. In those situations you often would like the garbage collector to reclaim memory even when references to an object still exist. The Java 2 Platform added a way to do exactly that.

If you wish to fine tune your application's use of memory, you have to dig in to the java.lang.ref package. It provides a way to relax

Continued on page 67.

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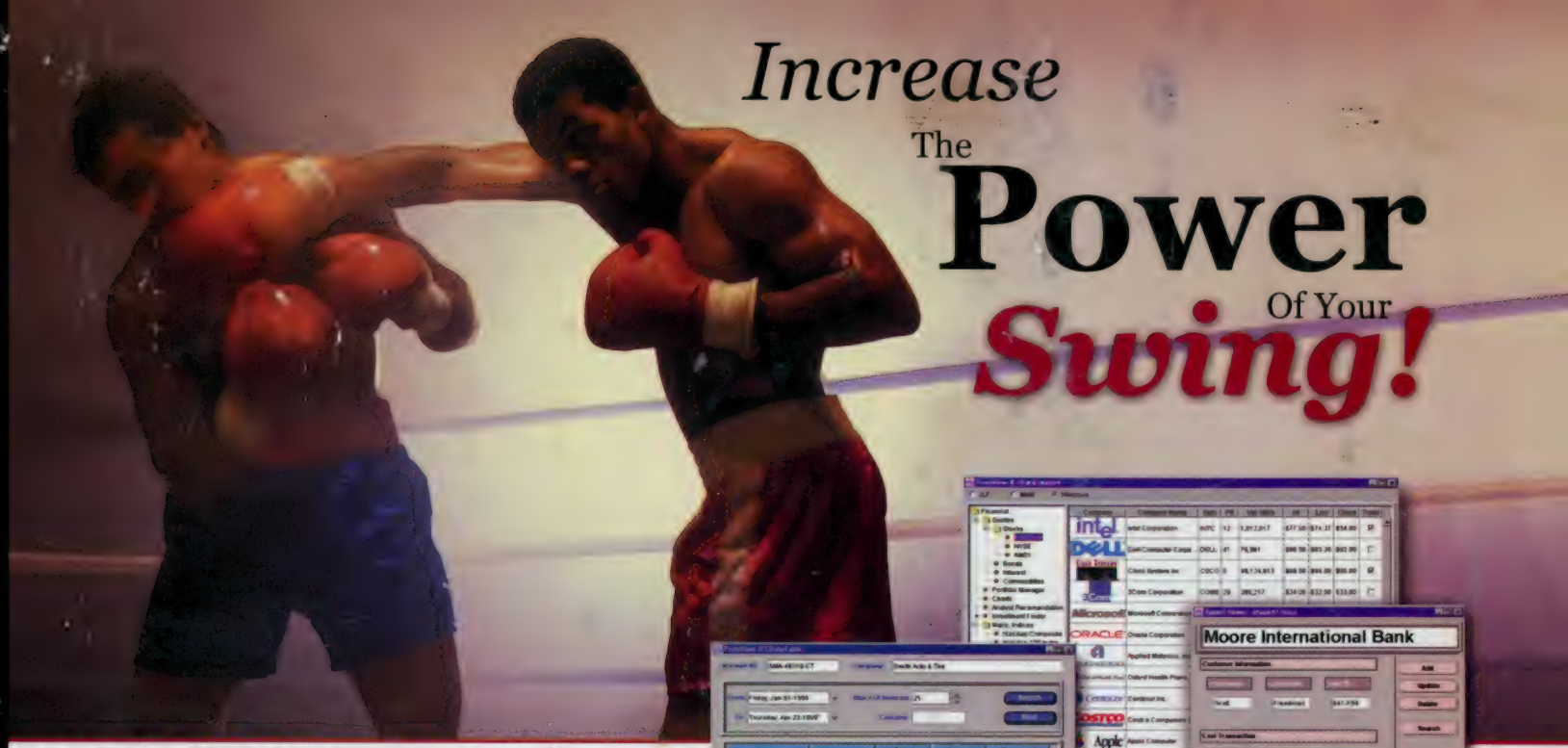

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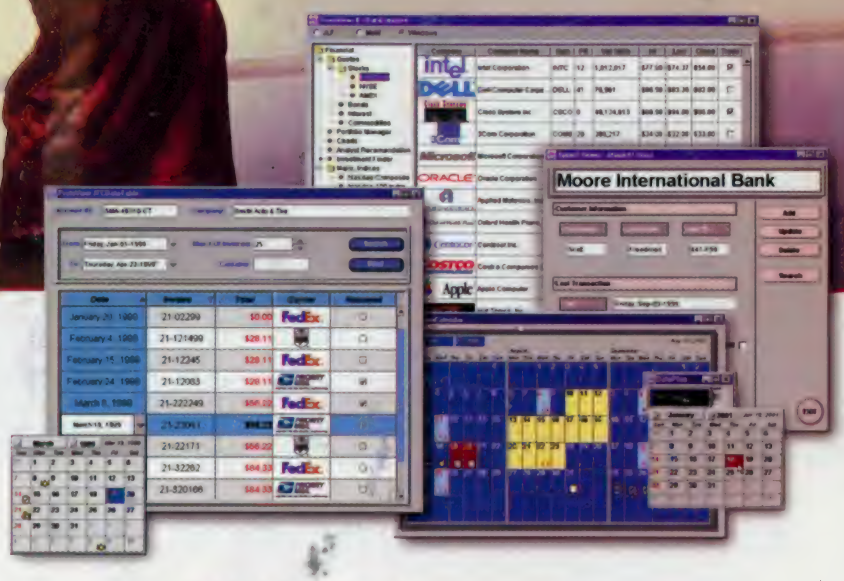

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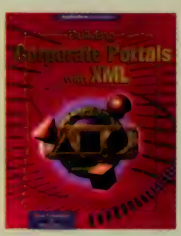

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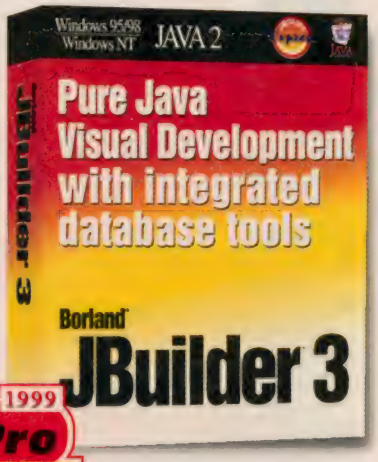

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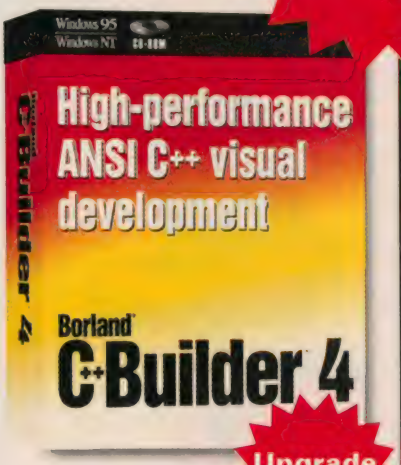

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DevX Price: $2,599

■ Application Server
Small Business Edition
for Windows NT
Format: CD ROM
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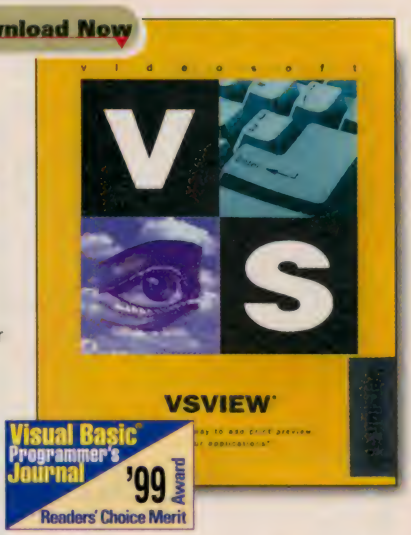

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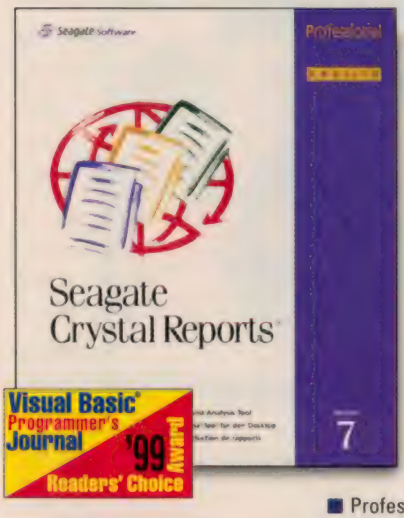

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  Pub: $299
  DevX Price: $289
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  Format: CD ROM
  Pub: $1,495
  DevX Price: $1,149
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  Format: CD ROM
  Pub: $859
  DevX Price: $809
- Professional Edition 5U w/subscription
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  DevX Price: $91
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  Pub: $799
  DevX Price: $559
- Professional Edition
  Competitive Version
  Special Upgrade
  Format: CD ROM
  Pub: $299.95
  DevX Price: $289
- Enterprise Edition
  Upgrade to
  to Professional
  Format: CD ROM
  Pub: $2,199
  DevX Price: $2,109
- Enterprise
  Edition New User
  Format: CD ROM
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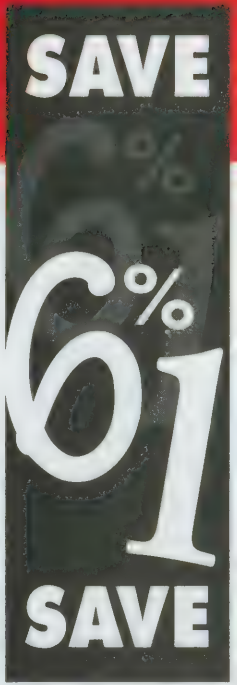

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